INSTRUCTION BOOK

FOR

POWER UNIT PE-207-A

MANUFACTURED BY

HILL DIESEL ENGINE COMPANY

DIVISION OF

ROGERS DIESEL AND AIRCRAFT CORPORATION

RESTRICTED

PUBLISHED BY AUTHORITY

OF

THE CHIEF SIGNAL OFFICER

Order No. 3112 — PHILA. — 43

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THE CHIEF SIGNAL OFFICER

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PE No.	PE-207-A
Mfr.	Hill Diesel Eng. Co.
RP No.	20060
Contr. No.	Hill Job 682A

CONDENSED DESCRIPTION OF EQUIPMENT

1. POWER UNIT PE-207-A herein described is a complete diesel engine-driven electric generating set designed to generate alternating current of 15KW capacity, 208/120 volts, three phase, 60 cycles, 1200 revolutions per minute. Frequency and speed regulation is held within plus or minus 1½%. Voltage regulation is automatically held within 5% when rated load at 80% power factor is reduced to zero. Also when the load is suddenly varied an amount corresponding to 50% of rated load at 80% power factor, the momentary voltage will not exceed plus or minus 7% of normal voltage and the voltage will return to within 2½% of normal voltage within 3 seconds. The entire power unit including switchboard is radio shielded. Overload protection is accomplished by the switchboard circuit breaker. Power Units may be operated in parallel through their respective switchboards by the "Dark Lamp Method"' (See page 62). Temporary instruction books including all necessary mounting and connection data are shipped with each power unit. All equipment, including spare parts, is rustproofed and boxed for export. This power unit consists primarily of the following major components:

2. ENGINE.— Hill Diesel Model 4R, four cylinder, 3½-inch bore x 5½-inch stroke, 212 cu. in displacement. The maximum rating of the engine at 1200 RPM is 34 BHP. The engine is radiator-fan cooled with the air flow moving outward from the front of the radiator and it operates on No. 2, 3 or 4 diesel or furnace oil. The engine is arranged for both 24V electric and hand starting. All moving and bearing parts of the engine are lubricated by force feed. This engine is completely described on pages 13 through 35 in this manual. Major engine accessories:

Lube Oil Filters.—	Cuno Type G, edge type, primary. Briggs G-800, cartridge type, by-pass.
Fuel Oil Filters.—	Cuno Type DS, edge type, primary. Fram F1104, cartridge type, secondary.
Emergency Stops.—	A Fulton No. 530 safety control is used to shut down the engine in event of high water temperature or low lubricating oil pressure.
Fuel Pump and Lift.—	Fuel transfer pump model AC-1523378 with an 8-ft. suction lift.
Air Cleaners.—	Two, oil bath type United air cleaners, model T045-11700.
Governor.—	Pierce model GC-438, centrifugal type.
Instrument Panel.—	Ammeter, oil temperature and pressure gauges, water temperature gauge, push button, alarm bell, switch and pilot light.

3. GENERATOR.— Made by General Electric Co. of Fort Wayne, Indiana, on their frame No. 944-E, rated at 15 KW, 208/120 volts, 60 cycle, three phase, four wire, 1200 RPM with direct connected 125 volt exciter on frame No. 810. It is direct connected through a Thomas No. 225-CM flexible coupling of the stainless steel disc type to the diesel engine. The complete engine-generator assembly is mounted on a substantial structural steel base of welded construction. The generator is completely described on pages 36 through 43.

4. SWITCHBOARD.— Made by the Kirkhof Electric Co. of Grand Rapids, Michigan. The panel is all steel with a self supporting angle iron frame. Maximum physical dimensions are given below. The panel equipment is completely described on pages 44 through 46 and completely listed on page 223.

5. BATTERIES AND ELECTROLYTE.— Four 6-volt, 3-cell, Exide batteries are furnished dry charged with electrolyte packed separately. These batteries are kept charged by a 24-volt charging generator which is mounted on the engine. See pages 34, 50-54, 129 and 192.

6. EXHAUST SILENCER.— Maxim 5SC, spark-arrester type. See pages 25, 50, 86 and 192.

7. FLEXIBLE EXHAUST HOSE.— In order to connect the 2½-inch inlet of the exhaust silencer to the 2-inch engine exhaust outlet the following flexible pipe is furnished. One 3-foot length of 2½-inch flexible pipe with a 2½ IPS x 3-inch nipple on one end and a 2 IPS coupling with a 2-inch close nipple on the other.

8. FUEL LINE AND FITTINGS.— Thirty feet of copper tubing with necessary fittings are furnished. See page 192.

9. SPARE PARTS.— Spare parts as listed on pages 233 and 234 are in a box inside the engine-generator export crate.

10. FUEL TANK.— Underground installation. Tank not furnished by engine-generator set manufacturer.

11. DIMENSIONS AND WEIGHTS OF MAIN COMPONENTS.—

Part	Length	Width	Height	Net Wt.	Gross Wt.
a. Engine	40⅜″	26″	40″	1440 lbs.	
b. Generator	36 13/16″	23½″	27¼″	1104 lbs.	
c. Engine-Generator Set	92″	30″	51″	3000 lbs.	3800 lbs.
d. Switchboard	30″	24″	76″	200 lbs.	420 lbs.

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THE SIGNAL CORPS STOCK NO. ASSIGNED TO THE POWER UNIT DESCRIBED IN THIS INSTRUCTION BOOK IS 3H4600-207A

THE SIGNAL CORPS STOCK NO. ASSIGNED TO THIS INSTRUCTION BOOK IS 3H4600-207A/B1

CONSOLIDATED PACKING LIST

HILL DIESEL ENGINE COMPANY **LANSING, MICHIGAN**

SIGNAL CORPS ORDER NO. 3112-PHILA.-43

Shipment made on..1943

To:

Bill of Lading No.. Total No. of Boxes: 80

Shipment consisting of 10 sets of Power Unit PE-207A, each set consisting of 8 boxes as follows:

BOX NO.	CONTENTS	CUBIC FEET	WEIGHT
1	Power Unit PE-207 A Battery Cables Battery Rack Exhaust Muffler Flexible Exhaust Pipe 30′ Length Copper Tubing Bag of Piping Fittings Set of Spare Parts	128	4,000
2	Switchboard	46	470
3	Batteries (two, 3-cell units)	3.5	200
4	Batteries (two, 3-cell units)	3.5	200
5	Battery Acid (three, 1-gallon bottles)	2.2	67
6	Battery Acid (three, 1-gallon bottles)	2.2	67
7	20 G-8 Cel. Filter Cartridges 20 C-1104-H Filter Cartridges	14	180
8	20 G-8 Cel. Filter Cartridges 20 C-1104-H Filter Cartridges	14	180

PE-207A — SERIAL NO.	MODEL 4R ENGINE SERIAL NO.	GENERAL ELECT. SERIAL NO.

A. DESCRIPTION OF EQUIPMENT

The power unit consists of a diesel engine connected by a flexible coupling to an alternating current generator. The engine and generator are mounted on a rigid structural steel sub base. A switchboard is also included in the equipment for connecting between the load and the generator to measure the output of the complete unit.

1. ENGINE. —

a. Description.— The engine is of the four-stroke-cycle, diesel, overhead valve type, similar to most other overhead valve engines. Four-stroke-cycle means the cylinder "fires" once for each four strokes of its piston or two complete turns of the crankshaft.

(1). Suction or Intake Stroke.— With the intake valve open the piston starts from the top of the cylinder and sucks air into the cylinder.

(2). Compression Stroke.— Near the bottom end of the intake stroke the intake valve closes and when the piston starts upward from the bottom of the cylinder the air, which was sucked in on the intake stroke, is compressed to about 525 pounds per square inch pressure. This rapid increase in pressure heats the air in the cylinder to about 1000° Farenheit. At a point just before the end of this compression stroke a measured amount of fuel is sprayed by the spray nozzle into a small chamber located in the head of the cylinder. Since this chamber is very small there is very little air in it. Combustion starts in this chamber causing a rapid rise in pressure. This increased pressure forces the partially burned fuel into the main cylinder and mixes with the remaining air there.

(3). Expansion or Power Stroke.— By the end of the compression stroke burning is well under way and the mixture of oil and air is expanding due to the heat caused by this burning. Both the intake and the exhaust valves are still closed. The piston starts downward on its power stroke taking the push given it by the burning mixture and passing on this push by means of the connecting rod to the crankshaft thus giving the crankshaft the power that makes it turn.

(4). Scavenging or Exhaust Stroke.— At a point near the end of the power stroke the exhaust valve opens. The piston then starts upward forcing the burned gases through the exhaust valve opening into the exhaust manifold and thru the muffler into the open air. At the end of this stroke the piston is at the top of the cylinder. At this point the exhaust valve closes and the intake valve opens. The piston is now ready to repeat the four-stroke-cycle.

The engine is cooled by an automotive type radiator and fan cooling system. This radiator also contains a separate core for cooling the engine lubricating oil.

Engine oiling or lubrication is of the force feed type. This means that every bearing in the engine itself is oiled by the force feed gear type lubricating oil pump mounted in the front part of the oil pan. The oil is carried in the oil pan or crankcase.

DESCRIPTION OF EQUIPMENT

b. Engine Specifications.—

Model	4R
Number of Cylinders	4
Bore (inches)	3½
Stroke (inches)	5½
Displacement (cubic inches)	212
Compression Ratio	15½ to 1
Firing Order	1-2-4-3
Horsepower (maximum) at 1200 Revolutions Per Minute	34
Capacity Lubricating Oil System (gallons)	7½
Capacity Lubricating Oil Pump (gallons per minute)	5
Capacity Cooling Water System (gallons)	7
Capacity Fresh Water Pump (gallons per minute)	25
Valve Diameter (inches)	$1\frac{5}{16}$
Number of Main Bearings	5
Main Bearing Diameter (inches)	$2\frac{15}{16}$
Center Main Bearing Length (inches)	$1\frac{5}{16}$
Front Main Bearing Length (inches)	3¼
Rear Main Bearing Length (inches)	3½
Main Bearing Projected Area (sq. inches)	31.3
Crank Pin Diameter (inches)	$2\frac{15}{16}$
Connecting Rod Bearing Length (inches)	$1\frac{5}{16}$
Connecting Rod Bearing Projected Area (sq. inches)	15.4

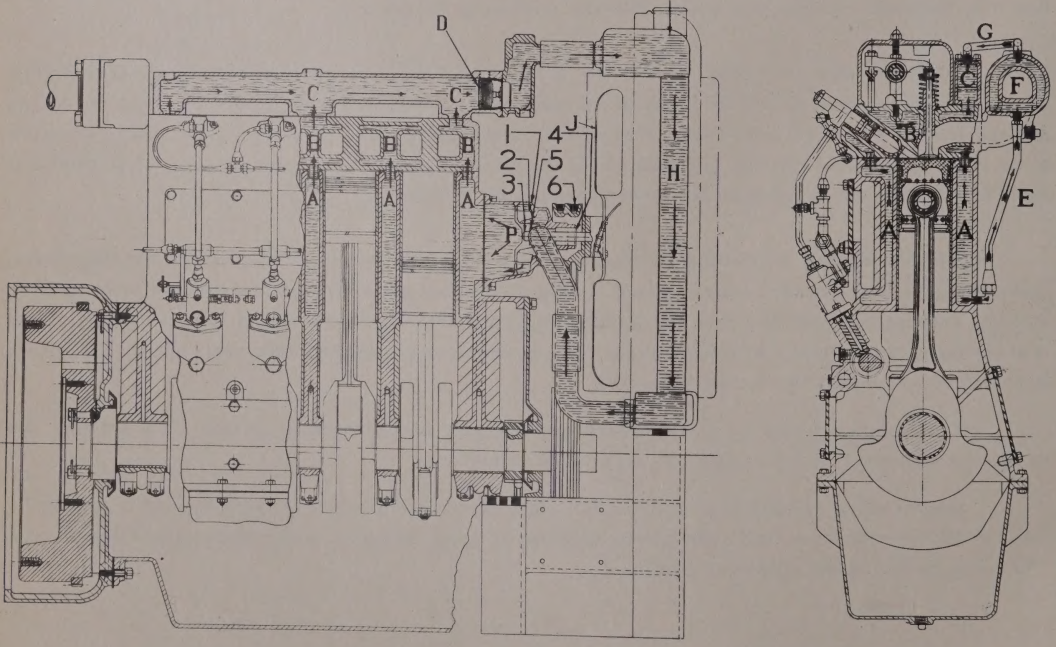


Fig. 1 — Cooling System

c. Engine Parts and Accessories.—

(1). Cooling System.— (Refer to Fig. 1, Page 14.) Cooling of the engine is accomplished by means of fresh water circulation forced by centrifugal pump (P) thru the cylinder block (A) cylinder head (B) and thru the water manifold (C) to the thermostat (D). Water is also forced from the block thru the by-pass line (E) to the exhaust manifold (F). From here the water passes thru by-pass line (G) to the water manifold.

After the engine reaches normal operating temperature thermostat (D) opens allowing the water to pass thru the top hose connection to the top of the radiator (H). As the water passes down thru the core of the radiator, fan (J) forces air thru the radiator dissipating the heat that was collected by the water passing thru the engine.

(a). Fresh Water Pump.— Circulation of water thru the cooling system is accomplished by means of a centrifugal type water pump mounted on the front end of the cylinder block. (Refer to Fig. 1, Page 14.) The pump consists of a pump body (1) impeller (2) impeller shaft (3) with dual sealed ball bearings (4) a water seal (5) and a "V" belt drive pulley (6) which also carries the cooling fan (J).

The water enters the pump from the side inlet passage to the center of the impeller. The water is forced outward by the centrifugal force of the rotating blades of the impeller into a channel cast in the pump body. This channel opens into the main body thus creating a high velocity into the cylinder block.

(b). Safety Control.— Refer to Page 35 for operation of safety control and its connection with the cooling system.

(2). Fuel Oil System.— (Refer to Fig 2.) Fuel oil is drawn from the fuel tank thru the metal-edge type filter (A) by the automotive type fuel transfer pump (B). After passing thru this pump it is forced thru a replaceable element type filter (C) safety control (D) to the fuel header (E). The

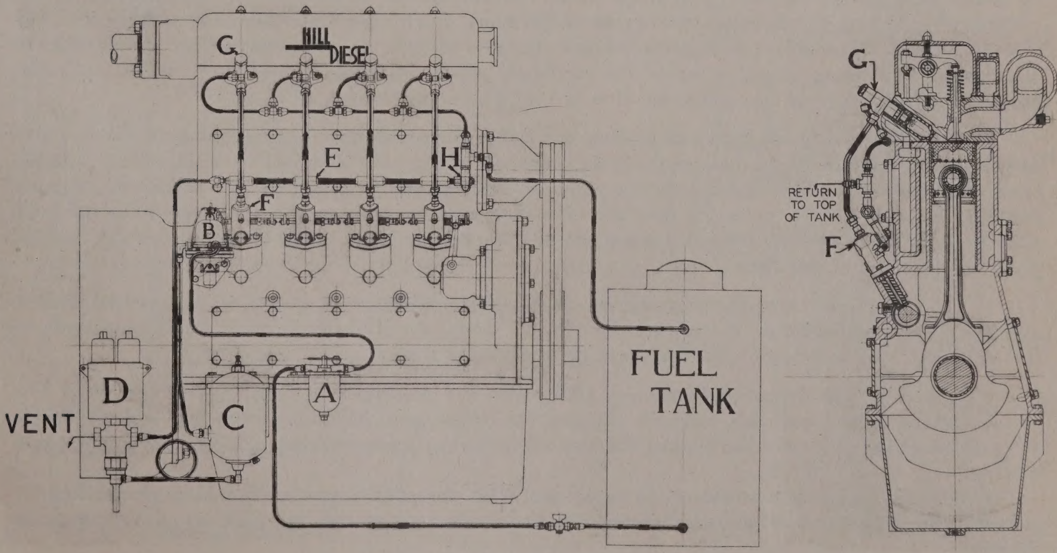


Fig. 2 — Fuel Oil System

fuel injection pumps (F) receive the fuel from the fuel header and force it thru the pintle type nozzles (G) into the cylinders.

The excess fuel delivered by the fuel transfer pump passes thru a relief valve (H) on the fuel header, to a pipe tee. The fuel seepage from the pintle type nozzles is carried by a small header to the above mentioned pipe tee. At this point this fuel combines with the excess fuel from the relief valve and is returned to the top of the fuel tank.

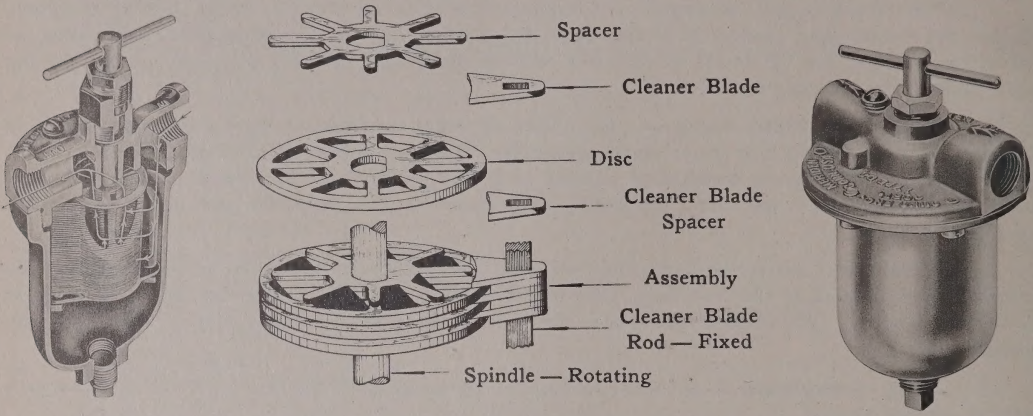


Fig. 3 — Metal Edge Type Fuel Oil Filter

(a). Metal-Edge Type Fuel Oil Filter.— (Refer to Fig. 3.) The metal-edge type fuel oil filter consists of a stack of extremely flat wheel shaped discs, each one accurately separated from the next by a thin metal spacer conforming in shape to the hub and spokes of the discs but without a rim. The thickness of the spacer determines the degree of filtration. In this particular filter the spacers are .0035 of an inch thick. The stack of discs, mounted on a rotatable shaft, is closed at one end, the spaces between discs "spokes" forming passages within the cartridges which are open at the other end to the outlet passage. The cartridge of this particular filter is 1¼" Dia. x 1⅝" long.

Fixed alongside the stack of discs is a rod holding knifelike stationary cleaner blades which extend into the slots between discs to the inside edge of the disc rim. The fuel oil is introduced into the space surrounding the filter element in the sump or housing, and is forced by the differential pressure between the inlet and the outlet, to flow thru the slots between discs to the passages within the filter element and thence to the outlet. All solids larger than the thickness of the spacer pieces are retained on the outer edges of the discs.

When the cartridge is turned thru a complete revolution by means of the external handle, all foreign solids collected on the surface are combed out by the stationary cleaner blades and settle to the bottom of the sump from which they can be periodically removed.

(b). Fuel Transfer Pump.— (Refer to Sub Contractors Parts List Page 195). The rotation of the engine camshaft eccentric actuates the rocker arm, which pulls the link and diaphragm and pull rod assembly downward against the diaphragm spring pressure creating a vacuum in the pump chamber.

On the suction stroke of the pump, fuel from the metal-edge type fuel filter enters thru the inlet into the sediment bowl and then passes thru the screen and on thru the inlet valve into the pump chamber.

On the return stroke, the diaphragm spring pressure pushes the diaphragm upward forcing fuel from the pump chamber through the outlet valve and out thru the outlet to the cartridge-type fuel oil filter.

When the entire fuel system is full, pressure builds up in the transfer pump chamber. This pressure will hold the diaphragm downward against the spring pressure where it will remain inoperative in the downward position until the fuel injection pumps need more fuel. The transfer pump actually operates in very short strokes while the engine is in operation. The length of the stroke varies with the engine load and speed. The rocker arm spring is merely for the purpose of keeping the rocker arm in constant contact with the camshaft eccentric.

(c). Cartridge-Type Fuel Oil Filter.— A cartridge-type fuel oil filter is installed in the fuel line as an added protection for the delicate fuel injection system parts. This filter is provided with a replaceable cartridge which is constructed as a complete unit. The outer portion of the cartridge is a lightly wound cotton roving which removes the coarse mechanical impurities. Nearer the center is a wrapping of cellulose wadding that removes the finer dirt. At the extreme center the cartridge has a very heavy filter paper, which prevents the passage of the most finely divided matter. The wound cotton roving is impregnated with a chemical treatment, which serves to remove gums and acids. This complete cartridge is encased in a thin metal perforated container for ease in handling.

(d). Safety Control.— Refer to page 35 for operation of safety control and its connection with the fuel oil system.

(e). Fuel Injection Pump.— The purpose of the fuel injection pump is to meter the fuel accurately and to begin delivering the fuel under high pressure to the fuel injection nozzle located in the cylinder head of the engine at a definite moment. Furthermore, the pump must deliver this measured

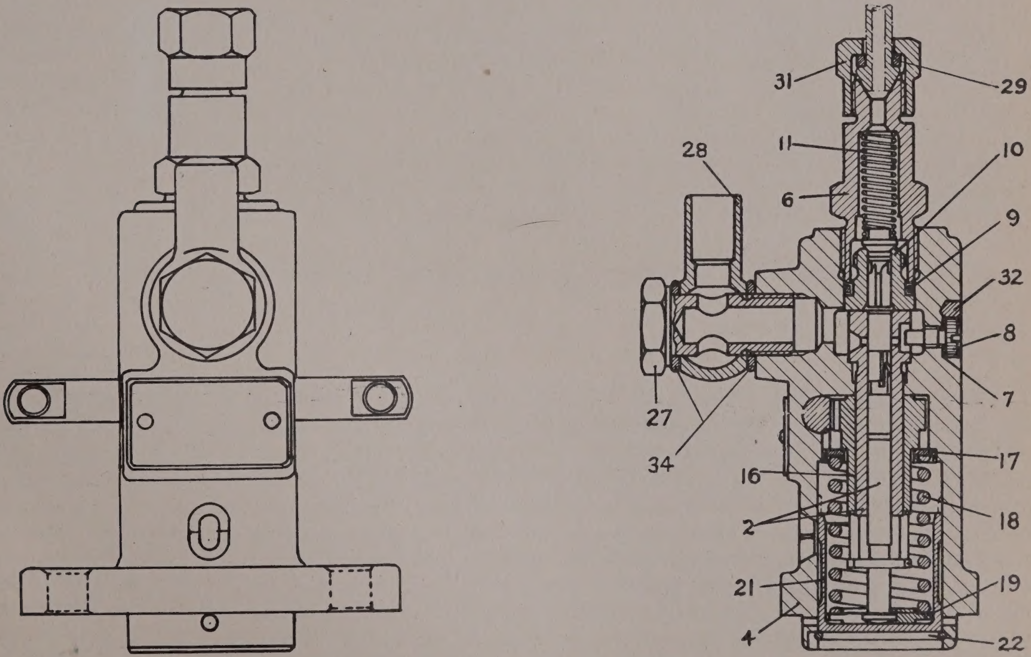


Fig. 4 — Fuel Injection Pump

fuel charge within a required time. Because of these exacting requirements, the manufacture of the vital parts demands the greatest accuracy and the handling of these parts must be done with care. For example, the fit of the plunger in the barrel of the injection pump is held to an accuracy of thirty-nine millionths of an inch (0.000039″), which is about equal to the one hundred twentieth part of the thickness of the average human hair. The close fit of the plunger in the barrel must be maintained in every assembly as, otherwise, the fuel delivery would not be uniform because of varying leakage. Some minute leakage of fuel oil by the plunger is, however, necessary since it serves the very important purpose of providing the needed lubrication for the plunger, moving up and down the barrel.

(Refer to Fig. 4, Page 17.) Each injection pump serves only one cylinder and is of the so-called constant stroke, cam-actuated, lapped plunger type. The injection pump consists chiefly of a housing (4) with integral mounting flange, plunger guide cup (21); pump element assembly comprising plunger and barrel (2), toothed control sleeve (16), plunger return spring (18), spring seats (17 and 19) and control rod (15). The housing also contains the fuel sump, delivery valve assembly (10) with gasket (9), delivery valve spring (11), delivery valve holder (6) and nipple nut (31) for connection of the high pressure discharge tubing.

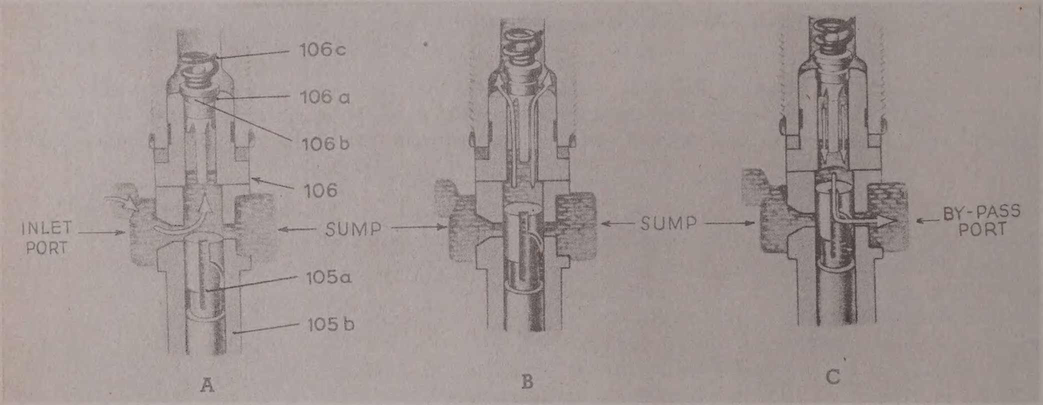


Fig. 5 — Cross-section of Barrel with various Plunger and delivery valve positions

(Refer to Fig. 5.) The fuel injection pump operates as follows: The fuel enters the sump thru the inlet connection in the upper part of the pump housing. As soon as the upper edge of the plunger (105a), during its downward stroke, opens the two radial opposite ports in the barrel, known as the inlet and by-pass ports, the fuel rushes into the barrel (105b) while the plunger is at the bottom of its stroke (A). During the first part of the upward stroke of the plunger, some of the fuel in the barrel is displaced back into the sump thru the inlet and by-pass ports, until these ports are completely closed. Shortly afterwards, the fuel is placed under pressure, the spring-loaded delivery valve (106b) is lifted off its seat, and the fuel is delivered thru the discharge tubing into the fuel injection nozzle (B). Delivery of the fuel ceases as soon as the helix on the plunger passes the by-pass port in the barrel, for at this instant the pressure chamber communicates with the sump by way of the vertical groove and helix on the plunger, allowing the fuel not yet delivered in the discharge tubing to by-pass back into the sump (C).

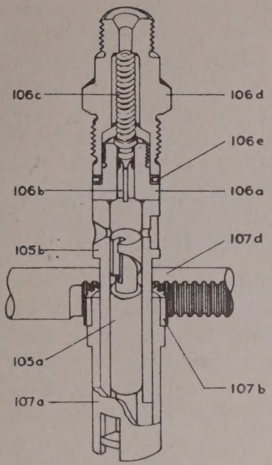


Fig. 6—Sectional view of fuel injection pump element with delivery valve assembly and delivery valve holder.

(Refer to Fig. 6.) The termination of the fuel delivery, which also controls the quantity of fuel delivered per stroke, is varied by turning the plunger in its barrel, i.e., by bringing the helix into various positions with relation to the by-pass port. To accomplish this, a control sleeve (107a) is slipped over the barrel (105b), the sleeve being provided with a toothed segment (107b) at its upper end and with two longitudinal opposite slots at its lower end, in which the cross flange of the plunger (105a) is guided. The teeth of the toothed segment engage corresponding teeth on the control rod (107d) and, by shifting the latter, either manually or automatically by means of the engine governor, the plunger is rotated in its barrel in either direction.

The less the control rod is moved away from its "stop" position and the less the plunger is thereby turned in its barrel, the sooner the helix opens the by-pass port and the smaller the fuel delivery per stroke will be (Refer to Fig. 7). The farther the control rod is moved away from its "stop" position and the farther the plunger is turned in its barrel, the later the helix opens the by-pass port and the larger the fuel delivery per stroke will be.

For maximum fuel delivery, the plunger, by moving the control rod farthest away from its "stop" position, is turned farthest in its barrel, resulting in very late opening of the by-pass port by the helix, i.e., in the maximum effective plunger lift. For zero delivery, with the control rod in the "stop" position, the plunger is turned in its barrel until its vertical groove registers with the by-pass port. In this position, the pressure chamber in the barrel is in constant communication with the sump during the entire mechanical stroke of the plunger; therefore, no fuel is delivered by the latter.

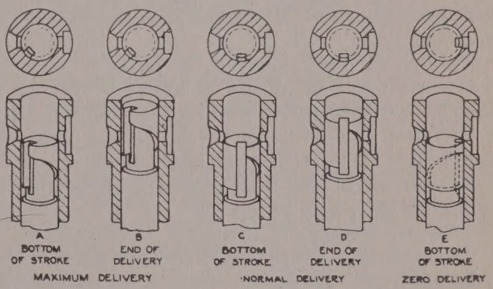


Fig. 7 — Barrel with various Plunger positions

When the helix of the plunger uncovers the by-pass port in the barrel during the latter part of the upward stroke, the pressure in the barrel is immediately released and the delivery valve is quickly returned to its seat by the combined action of its spring and the great difference in pressure which then exists between the barrel and the discharge tubing. This closes off communication between the pressure chamber in the barrel and the fuel injection nozzle, until the next delivery stroke takes place. In returning to its seat, the delivery valve performs a double function: first, it prevents excessive draining of fuel from the discharge tubing during by-passing, as well as during the suction stroke of the plunger; second, it relieves the pressure in the discharge tubing. This pressure relief is accomplished by means of the accurately lapped relief or displacement piston provided on the delivery valve proper below its conical seat and above its flutes. (Refer to Fig. 8, Page 20.)

Before the delivery valve actually reseats, after the helix of the plunger has uncovered the by-pass port in the barrel, it reduces the pressure in the discharge tubing by increasing the volume therein by a quantity equal to the volume of the relief piston, for the latter slides down into the delivery valve seat with a plunger-like action. As a result of this rapid reduction in pressure, the nozzle valve at the other end of the discharge tubing "snaps" into its seat, thus instantaneously terminating the fuel injection from the fuel injection nozzle and thereby eliminating "dripping."

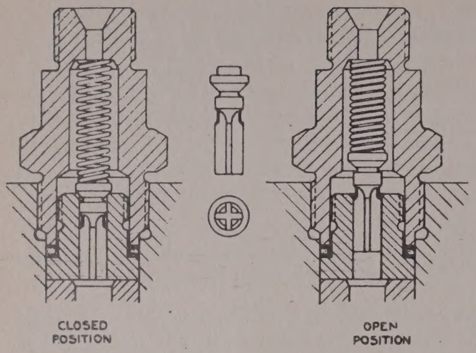


Fig. 8 — Cross-section of delivery valve assembly

The external control of the fuel delivery per stroke is accomplished by means of the control rod, one end of which is connected to the governor of the engine. There is a certain amount of dead movement of the control rod in its "stop" position, i.e., the rod must be moved about $\frac{3}{16}$" from its full stop position before the delivery of the fuel commences. From that point on, however, the quantity of fuel delivered is directly proportional to the movement of the control rod.

In the diesel engine, speed and power output are controlled solely by a variation of the amount of fuel injected into the combustion chamber. As clearly explained in preceding paragraphs, this variation of the amount of fuel delivered by the fuel injection pumps to the fuel injection nozzles is regulated by the simple and foolproof action of the helix on the plungers.

(f). Fuel Injection Nozzle and Holder.— The purpose of these units is to direct the metered quantity of fuel received from the fuel injection pump into the engine combustion chamber in a definite spray pattern and in such a manner as to produce the most efficient engine performance.

1. Fuel Injection Nozzle.— (Refer to Fig. 9, Page 21.) The fuel injection nozzle is of the closed, differential-needle, hydraulically-operated type. It utilizes a spring-loaded valve with a seat near the spray orifice to close the orifice after each injection of fuel into the engine combustion chamber. The valve is operated hydraulically by the pressure of the fuel oil being delivered by the fuel injection pump.

The injection nozzle consists of only two parts: the nozzle body and the nozzle valve, shown separately in Fig. 10, Page 21. These parts are made of alloy steel, heat-treated by special methods to minimize wear and promote durability. The body and valve is lapped to form a mated assembly. The lapped fit is so close that measurement is impracticable except by a specially designed hydraulic instrument. Therefore, body and valve CANNOT BE EXCHANGED SINGLY, BUT MUST BE KEPT TOGETHER AT ALL TIMES.

The fuel injection nozzle used in this engine is of the pintle type as shown by Fig. 11. The nozzle valve carries an extension at its lower end in the form of a pin (called pintle) which protrudes through the closely fitting hole in the nozzle bottom. This requires the injected fuel to pass thru an annular orifice, thus producing a hollow, cone-shaped spray, the nominal included angle of which is 4 degrees because of the combustion system requirement. The projection of the pintle thru the nozzle orifice induces a self-cleaning effect which is an important feature. This discourages accumulation of carbon at this point and appreciably increases the permissible length of service without attention.

2. Fuel Injection Nozzle Holder.— (Refer to Fig. 9, Page 21.) The fuel injection nozzle holder is used to hold the nozzle in its correct position in the engine cylinder head and to provide a means of conducting fuel oil to the injection nozzle. The nozzle holder also contains the necessary spring and means of pressure adjustment to provide proper action of the nozzle valve.

The injection nozzle holder body contains drilled passages for conducting the fuel from the inlet connection to the nozzle. The lower end of the body is provided with an accurately ground and lapped surface which makes a leak-proof and pressure-tight seal with the corresponding lapped surface at the upper end of the nozzle. This feature eliminates the necessity of a gasket and permits the nozzle to be easily removed from and reassembled to the holder. The nozzle is secured by means of the cap nut as shown.

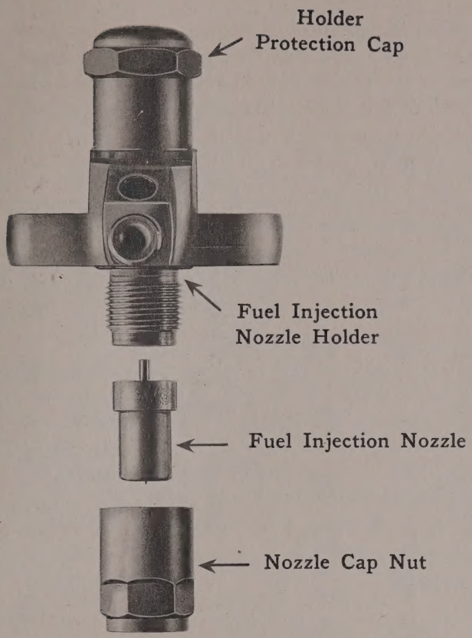


Fig. 9 — Fuel Injection Nozzle and Holder

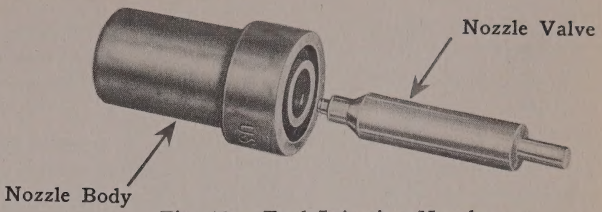


Fig. 10 — Fuel Injection Nozzle

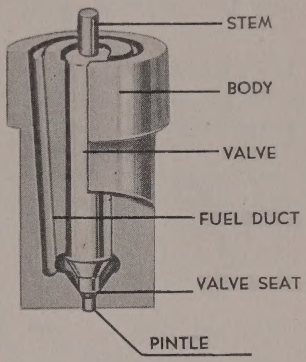


Fig. 11 — Cross-section of Fuel Injection Nozzle

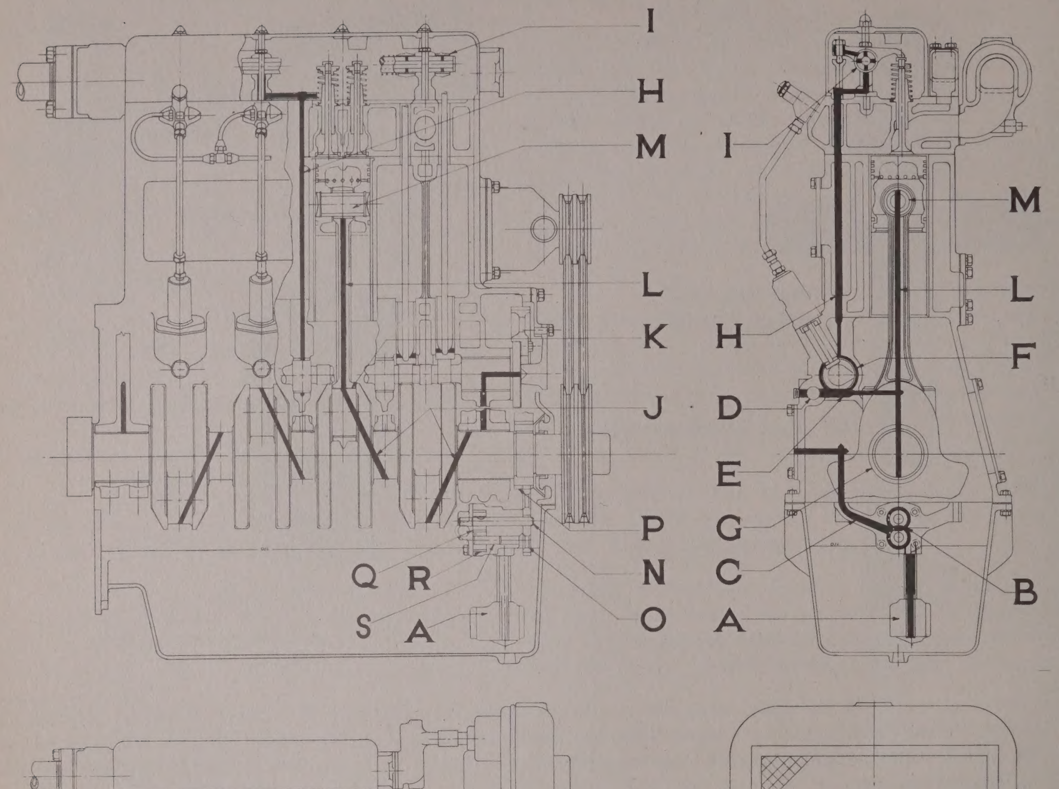
At its upper end, the nozzle valve has an extension of reduced diameter, referred to as the "stem," which makes contact with the lower end of the spring loaded spindle. Adjustment of the nozzle valve opening pressure is accomplished by means of the spring pressure adjusting screw under the protection cap.

Operation of the fuel injection nozzle and holder assembly is simple and positive. The metered quantity of fuel from the injection pump enters the holder thru the inlet connection and passes thru connecting ducts to the pressure chamber just above the nozzle valve. At the instant the pressure of the fuel acting on the differential area of the valve exceeds the pre-determined spring load, it will lift the valve from its seat and fuel will flow from the nozzle until delivery from the injection pump ceases. Then, a positive, instantaneous cut-off of fuel occurs as the valve is snapped to its seat by the spring force which eliminates the possibility of after dripping or dribbling.

A certain amount of seepage of fuel between the lapped guide surfaces of the nozzle valve and its body is necessary for lubrication. This leakage oil accumulates around the spindle and in the spring compartment, from which it drains through the leak-off connection provided for that purpose.

(3). Lubricating Oil System.— (Refer to Fig. 12, Page 22.) All working parts of the engine are lubricated by oil drawn thru a coarse screen (A) into the lubricating oil pump (B). This pump forces the oil thru a drilled passage (C) into the outside of the cylinder block casting thru tube (2) a metal-edge filter (3) tube (4), lubricating oil cooler (5) tube (6) and then returns the oil to the lubricating oil header (D) which is a drilled hole running the entire length of the cylinder block. Just ahead of the lubricating oil cooler, a relief valve and by-pass tube (7) is provided to allow the lubricating oil to feed directly back into the engine if the lubricating oil cooler should become plugged.

A by-pass line (8) is also provided to allow lubricating oil to be forced thru the cartridge filter (9), tube (10) into the oil filler cup from which point the oil drains directly into the base of the engine.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TEE
3
DISCHARGE FROM LUBE OIL PUMP
8
OIL COOLER
9
5
RELIEF VALVE
7
6
4
3
C

Fig 12 — Lubricating Oil System

Oil is also forced from the lubricating oil header (D) thru tube (11) into the governor (12) from which point the oil also returns to the base of the engine. A pipe tee at the rear end of the lubricating oil header allows lubricating oil to be forced thru tube (13) to the oil pressure gauge (14) and thru tube (15) to the safety control (16).

Lubricating oil is also forced from the lubricating oil header (D) thru drilled passages (E) to all camshaft bearings (F) and to all main crankshaft bearings (G). Lubricating oil from the camshaft bearings is also forced thru tube (H) to valve rocker arms (I) and lubricating oil from the main crankshaft bearing is forced thru drilled passages (J) in the crankshaft to the connecting rod bearings (K). The lubricating oil from the connecting rod bearings is forced thru the drilled connecting rods (L) to the piston pin (N). This oil lubricates the cylinders and then falls back thru the crankcase into the oil pan to begin a new cycle.

(a). Lubricating Oil Pump.— (Refer to Fig. 12, Page 22.) The lubricating oil is circulated by means of a gear-type lubricating oil pump (B) mounted on the cylinder block under the front main crankshaft bearing. The pump body is a machined cast iron casting. The pump body contains two hardened steel shafts. The longer shaft (N) carries the external driving gear (O) which meshes with the crankshaft pinion gear (P). This shaft also carries an internal driving gear (Q) which meshes with the internal driven gear (R) carried on the short shaft (S). The internal gears are the gears that actually pump the lubricating oil. There is a spring-loaded, plunger-type relief valve built into the pump end cover plate to regulate the lubricating oil pressure. This relief valve begins to open when the lubricating oil pressure reaches approximately 45 lbs. per square inch and allows the excess lubricating oil to by-pass directly into the oil pan.

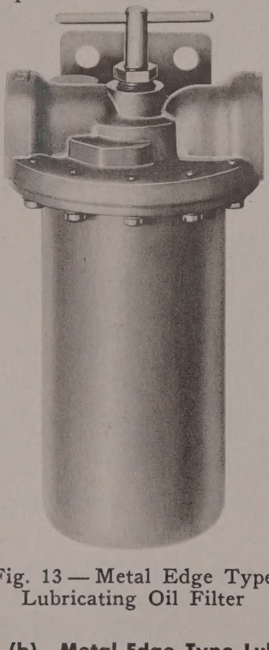

Fig. 13 — Metal Edge Type Lubricating Oil Filter

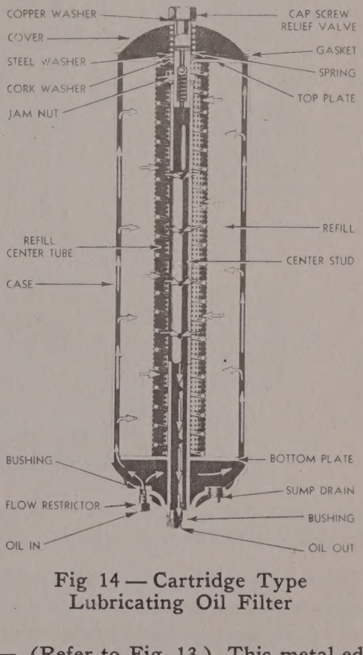

Fig 14 — Cartridge Type Lubricating Oil Filter

(b). Metal-Edge Type Lubricating Oil Filter.— (Refer to Fig. 13.) This metal-edge lubricating oil filter is constructed exactly like the metal-edge fuel oil filter discussed in a previous paragraph. The spacers are also .0035″ thick. The cartridge, however, is 1¼″ in diameter by 4½″ long, or approximately three times the size of the previously mentioned metal-edge type fuel oil filter cartridge.

(c). Cartridge-Type Lubricating Oil Filter.— (Refer to Fig. 14.) The engine lubricating oil pump forces oil into the cartridge-type filter thru the filter inlet. The oil then flows up thru the filter to the cellulose cartridge (refill). Part of the oil is forced thru this cartridge which cleans the oil by removing the dirt. The oil that does not pass thru this cartridge flows up to the top of the filter, enters the hollow cap screw, flows downward to the relief valve built within the hollow center stud and discharges thru the relief valve. This spring-loaded relief valve is set to maintain the correct pressure differential on the filter cartridge for proper cleaning of the oil. The oil by-passed thru the relief valve and the oil cleaned by the filter cartridge enters and flows down thru the hollow center stud, and discharges out of the filter thru the outlet. Sludge from the dirty oil will settle to the bottom of the filter and may be removed periodically thru the drain plug. The minimum lubricating oil pressure for normal operation of this filter is approximately 18 lbs. per square inch. This particular filter is designed especially for small diesel engines which operate at 40 h.p. or less.

(d). Safety Control.— Refer to page 35 for operation of safety control and its connection with the lubricating oil system.

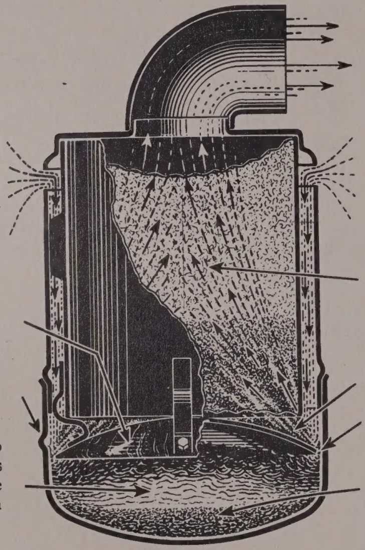
Clean Air to Engine
Dust Laden Air
Air Intake Around Entire Cleaner
Filter Element in Which Continuous Wash of Oil Removes the Remainder of Dust
Baffle to Prevent Excessive Amount of Oil Being Drawn Into Filter at High Motor Speeds
Oil Spray in Air Stream
Bead Indicating Proper Oil Level
Large Percentage of Dust Strikes Oil and is Removed at this Point
Oil Reservoir Into Which Dust is Washed. Remove Cup and Clean Regularly
Dirt Deposit

Fig. 15 — Oil Bath Air Cleaner

(4). Air Intake System.— The suction stroke of each piston draws air thru two air cleaners of the heavy-duty oil bath-type, into the engine cylinders.

(Refer to Fig. 15.) Air enters the cleaner at the annular opening near the top of the cleaner body and passes downward to the bottom of the filter chamber where it bubbles thru the oil and passes upward into the filter. A large portion of the dust particles floating in the air are caught in the oil cup of the cleaner where mixing of the air and oil first takes place. The continuous washing action in the filter element removes the remainder of the dust particles from the air stream. These dust particles drain back into the oil cup and eventually settle out of the oil onto the bottom of the oil cup. The continuous washing action which takes place in the filter chamber not only removes the finer dust particles from the air stream, but also keeps the filter element free of all dirt.

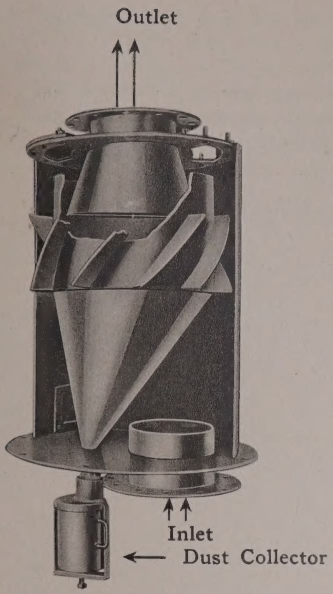

Fig. 16 — Exhaust Silencer

(5). Exhaust System.— Air which is exhausted from the engine cylinders passes into a water cooled exhaust manifold and into the atmosphere thru the connecting flexible exhaust pipe and exhaust silencer.

(Refer to Fig 16.) The exhaust silencer is of the spark-arrestor type and is securely welded of sheet and plate steel. A removable dust collector is located at the bottom of the silencer to allow the unit to be easily cleaned. Large hand-holes are provided and all parts of the interior are easily reached for inspection and cleaning. This model silencer is designed for vertical installation only, or at the most, not more than 20° from vertical.

(6). Cylinder Head.— The cylinder head, (Fig. 17), is a one-piece alloy iron casting securely held to the top of the cylinder block by heat-treated alloy steel studs.

The cylinder head contains openings for one inlet valve, one exhaust valve, and a fuel injection nozzle for each cylinder in the engine. Hardened valve seats for the inlet and exhaust valves are shrunk into the cylinder head casting, thus furnishing accurate seating for the valves under varying temperature changes as well as prolonging the life of the cylinder head. These valve seats are accurately ground to very close limits and their freedom from warpage under ordinary working conditions reduces valve grinding to a minimum.

To insure efficient cooling, each fuel injection nozzle is inserted in a brass adapter which has been pressed into the cylinder head on top of the pre-combustion chamber. All inlet and exhaust valves, pre-combustion chambers, fuel injection nozzle adapters, as well as both inlet and exhaust passages are completely surrounded by water.

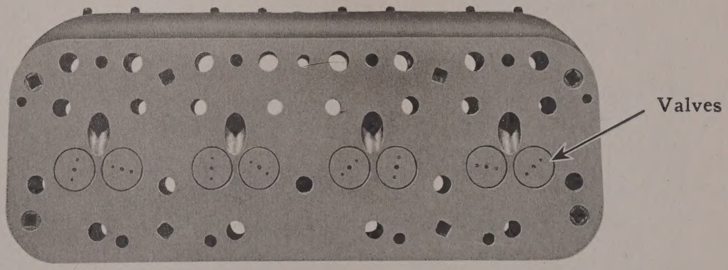

Fig 17 — Cylinder Head

(7). Valve Operating Mechanism.— The valve operating mechanism, (Fig. 18, Page 26), is an assembly of parts which work in between the camshaft and the valves thus permitting the camshaft to control the time that the fresh air enters and the exhaust gasses leave the engine cylinders.

Two drop-forged steel rocker arms are provided for each cylinder, one for the inlet valve and one for the exhaust valve. The rocker arms are assembled on a shaft in sets of four with two support brackets for each two cylinders. The rocker arm assembly is held to the cylinder head by studs extending thru the brackets and shaft. There is a hardened steel cap on top of each valve to reduce wear on the end of

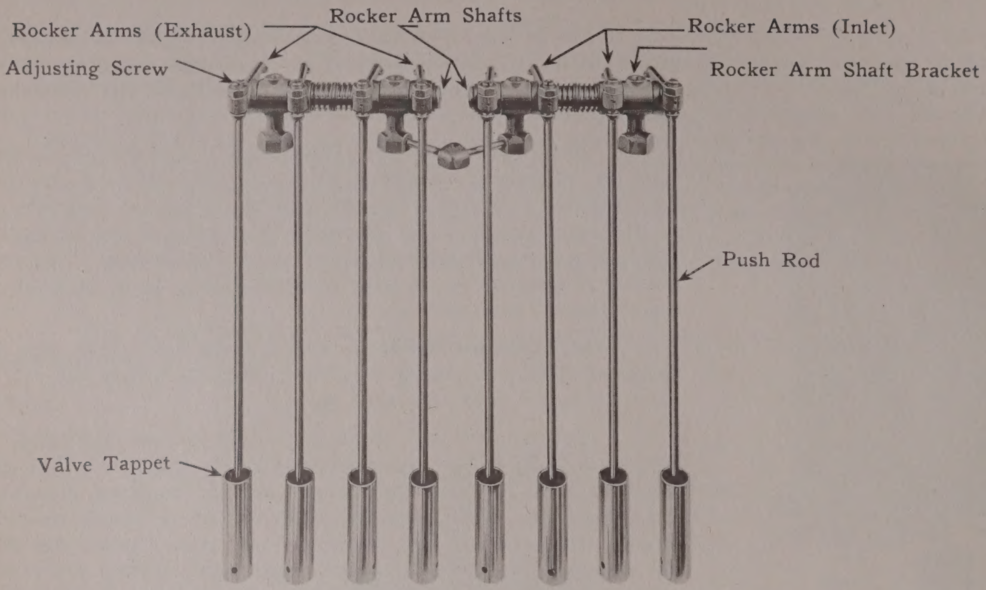
Rocker Arms (Exhaust)
Rocker Arm Shafts
Rocker Arms (Inlet)
Adjusting Screw
Rocker Arm Shaft Bracket
Push Rod
Valve Tappet

Fig. 18 — Valve Operating Mechanism

the valve stem and the end of the rocker arm. Each rocker arm has an adjusting screw with a ball at its lower end, fitting into socket on the top end of the push rod, thus providing a universal joint at this point. The push rod extends down thru passages in the cylinder block into a hardened steel tappet that is operated by the camshaft.

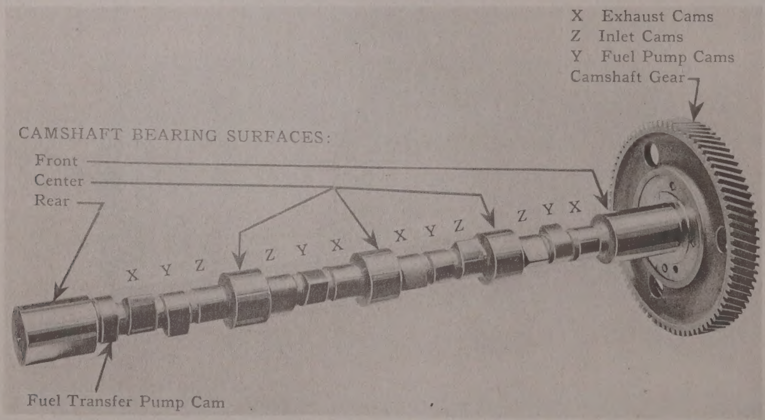
X Exhaust Cams
Z Inlet Cams
Y Fuel Pump Cams
Camshaft Gear
CAMSHAFT BEARING SURFACES:
Front
Center
Rear
X Y Z
Z Y X
X Y Z
Z Y X
Fuel Transfer Pump Cam

Fig. 19 — Camshaft and Gear

(8). Camshaft.— The camshaft, (Fig. 19), is a one piece casting made of alloy cast iron and is located in the upper part of the crankcase. Cams for operating the fuel transfer pump, fuel injection pumps, exhaust and inlet valves, are all part of the camshaft. All cams and camshaft bearing surfaces are hardened and ground to provide a hard wearing surface. The camshaft is supported in one piece steel-backed, babbit-lined bearings, one between each cylinder and one at each end, because it is of the greatest importance that it remains perfectly rigid. Obviously when the engine is running, a considerable force is exerted on the push rods by the cams at each instance when the valves are to open. If the camshaft is flexible enough to "give," the timing of the valves will be later than they are set for. The camshaft is driven at half crankshaft speed by the camshaft gear which meshes with the crankshaft gear. This gearing down is made necessary because each valve operates once for each two revolutions of the crankshaft.

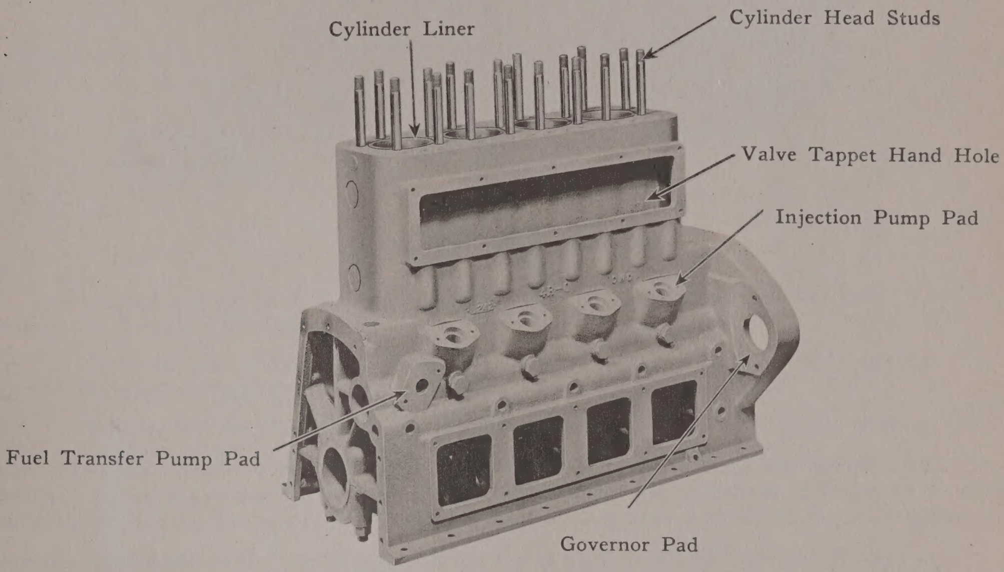

Fig. 20 — Cylinder Block and Crankcase

(9). Cylinder Block and Crankcase.— The cylinder block and crankcase, (Fig. 20,) which is the main structural part of the engine, is a one-piece casting made of alloy cast iron.

Cross members are cast as part of the crankcase to add strength and rigidity which insures perfect alignment of bores and bearings. The cylinders are bored and honed to close limits to insure perfect fit of the cylinder liners. A solid copper ring is used between the cylinder liner and the cylinder head to seal the compression. Neoprene seals are used around the valve push rod passages, vertical oil tube, and water passes between the cylinder block and cylinder head to prevent oil and water leaks.

Drilled and reamed holes in the cylinder block act as guides for the inlet and exhaust valve tappets. Similar holes are provided for the fuel injection pump tappets. A large hand hole is provided for easy access to the valve tappets.

(10). Cylinder Liners.— The cylinder liners, (Fig. 20,) are of the dry-type made of hardened alloy cast iron. They are accurately honed to a very smooth finish and machined with a light press fit in the cylinder bore. A flange at the top of the cylinder liner fits into a recess in the top of the cylinder block, insuring the proper position in the cylinder block.

Even temperature and minimum distortion are insured by cooling each cylinder liner over its entire length.

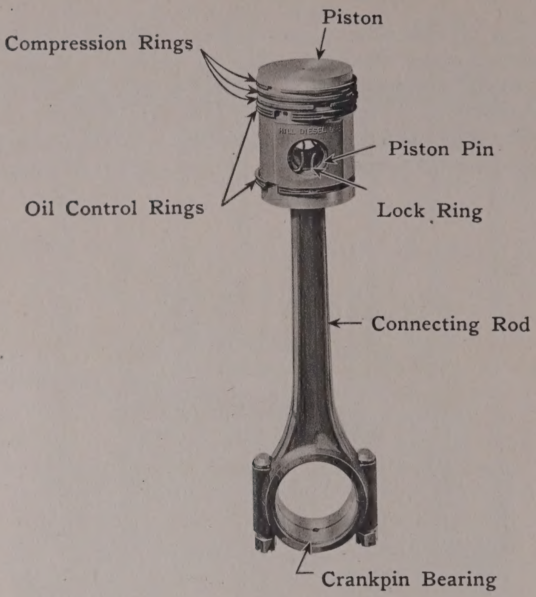

Fig. 21 — Piston and Connecting Rod

(11). Piston and Connecting Rod Assembly.— (Fig. 21.) The piston and connecting rod assembly, is an assembly of parts which transmits the forces of combustion-expansion to the crankshaft. The vertical motion of the piston is converted into rotary motion by the connecting rod and the crankshaft.

(a). Piston.— The piston is an accurately ground casting made of heat-treated aluminum alloy. The head of the piston as well as the piston pin bosses are reinforced with heavy fillets in the casting to add strength and rigidity. The piston pin hole is bored and reamed accurately to receive the hardened, semi-floating, piston pin. After the piston pin has been installed it is locked in place by a lock ring at each end.

Each piston is fitted with five cast iron rings of the conventional cut-joint type. Three ⅛″ wide compression rings are placed at the top of the piston. Two ¼″ wide oil control rings are used one above the piston pin boss and one near the bottom of the piston.

(b). Connecting Rod.— Each connecting rod is made of drop-forged, heat-treated alloy steel, and forged to an "I" section with a closed hub at the upper end and a cap at the lower end.

The crankpin bearing halves are steel-backed, cadmium-silver lined shells of the precision type, without shim adjustments. The upper and lower halves of the connecting rod bearing shells are exactly alike. A bronze bushing is pressed into the closed hub at the upper end of the connecting rod to provide a bearing surface for the piston pin.

(12). Crankshaft.— The crankshaft, (Fig. 22, Page 29,) is a casting made of a special alloy cast iron. All bearing surfaces are accurately ground and highly polished. Counter weights are cast as a part of the crankshaft to achieve complete static and dynamic balance of the rotating parts.

The crankshaft has five main bearings, one between each cylinder and one at each end to insure a very rigid support.

Located at the front end of the crankshaft is the crankshaft gear which drives the rest of the gears in the gear train.

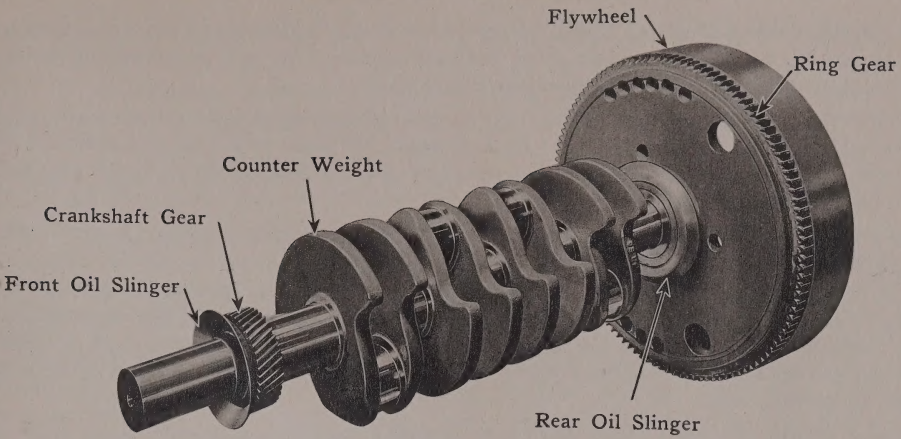
Flywheel
Ring Gear
Counter Weight
Crankshaft Gear
Front Oil Slinger
Rear Oil Slinger

Fig. 22 — Crankshaft Assembly

An oil slinger is located at each end of the crankshaft to prevent lubricating oil from being thrown out around the crankshaft.

A cast iron flywheel is securely bolted to the rear end of the crankshaft to store up energy to keep the crankshaft turning between power impulses.

A heat-treated steel ring-gear is shrunk onto the rim of the flywheel which meshes with the starter pinion gear for starting the engine.

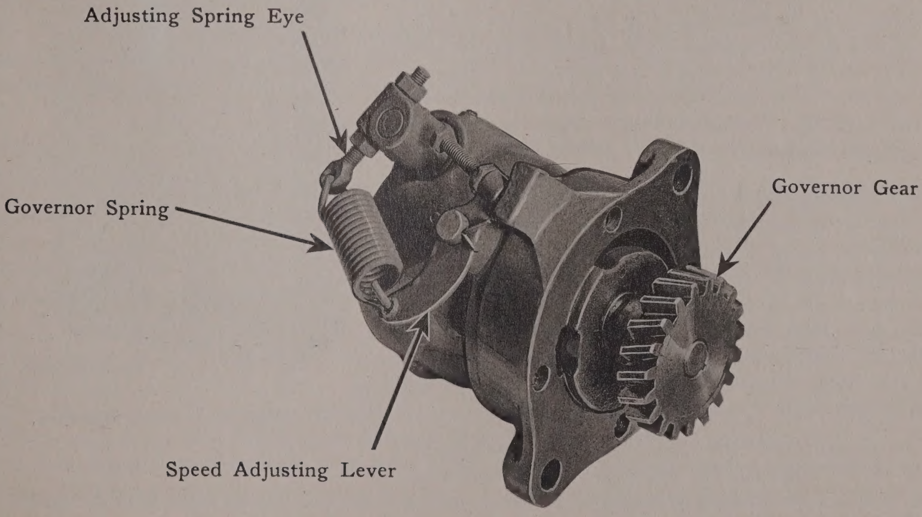
Adjusting Spring Eye
Governor Spring
Governor Gear
Speed Adjusting Lever

Fig. 23 — Engine Governor

(13). Governor.— The engine governor, (Fig. 23,) is of the centrifugal type. The governor spring force tends to hold the fuel metering shaft in the wide open position; the weight force, opposing the spring, tends to shut off the supply of fuel.

The governor spring is located outside of the governor case with one end hooked to the speed adjusting lever and the other end anchored to an auxiliary adjusting spring eye on the rocker shaft. Increasing tension on the governor spring increases engine speed.

Inside of the governor the weights are hung on a weight spider fastened to the rotating drive shaft. As the weights revolve, centrifugal force tends to throw the mass of the weights outward. The weights pivot on the weight pins, converting the centrifugal force to a thrust force against the thrust sleeve which slides on the drive shaft.

Movement of the thrust sleeve is transmitted to the rocker shaft by means of the yoke which contacts the thrust bearing pressed on the thrust sleeve.

When the engine is not running, the governor spring holds the fuel metering shaft wide open. When the engine is started, the weights swing out and move the rack shaft toward the closed position. The weights continue to move out until the weight force and the opposing spring force are in balance. With the weight and spring force in balance, the fuel metering shaft will be in position to maintain the predetermined governed speed.

If load is applied, the engine slows down and the weight force decreases — the spring force will then open the fuel metering shaft. If the load is thrown off, engine speed will go up and the weight force will increase — closing the fuel metering shaft to maintain the governed speed.

(14). Electric Starting and Battery Charging System. —

(a). Push Button and Starting Switch.— The push button, (Fig. 24,) is mounted on the engine instrument panel. When the button is depressed two separate sets of contacts are closed simultaneously. These contacts are connected to the starting motor control and complete the circuit to make the control operate. The control box consists of two solenoid switches and a time delay relay. When the push button is operated one of the solenoid switches closes immediately and connects the starting motor to the battery thru a resistor. This resistance reduces the large current that would flow thru a stopped motor. When the motor begins to revolve the time delay relay operates and excites the second solenoid switch. When this switch closes the resistance is shorted out and the full battery voltage is applied to the starting motor.

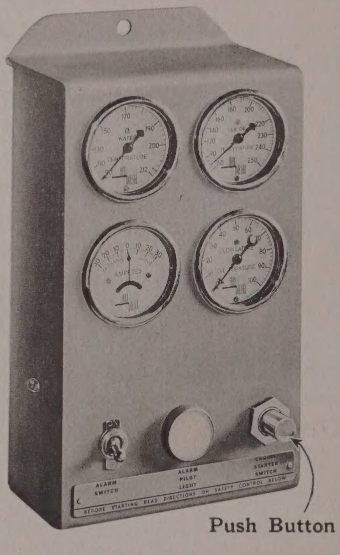

Fig. 24 — Control Panel

(b). Starting Motor.— (Refer to Fig. 25, Page 32.) The starting motor is designed to crank the engine when the starting switch closes the circuit between the storage battery and the motor. It consists of six main sub assemblies which are: the frame and field, the armature, the commutator end head, the pinion housing, the Bendix drive and the motor control. The armature and frame and field are similar in construction and purpose to the charging generator parts except the windings are of heavy copper bars instead of the wires used in the charging generator.

The commutator end head supports a bearing and four brush holders and brushes. The pinion housing is a cast iron housing for the Bendix drive and also provides the motor mounting lugs. The Bendix drive is an automatic clutch that engages the starting motor with the engine flywheel when the motor cranks the engine and disengages when the engine starts. It consists of a threaded sleeve fastened to the armature shaft thru a drive spring and a pinion mounted on the threads of the sleeve. When the starting circuit is closed the armature revolves, turning the sleeve within the pinion, and forces the gear forward meshing it with the flywheel gear. The sudden shock of meshing is absorbed by the spring. When the engine starts the pinion is driven faster than the sleeve and is forced back along the threads, automatically demeshing it from the flywheel.

(c). Charging Generator.— (Refer to Fig. 26, Page 32.) The generator is a device for changing mechanical energy into electrical energy. It is the only source of electricity and supplies all the power for starting and other accessories. The battery is not a source of electricity but only a storage reservoir. In starting for instance, the battery supplies the energy but as soon as the engine starts, the generator begins to replace the electricity taken from the battery.

The generator consists of four main sub assemblies. These are: the frame and field, the commutator end head, the drive end head and the armature assemblies. The frame and field consists of the frame which supports the components of the generator, the pole pieces and the field coils. The coils supply the magnetic field which is necessary for generating electricity; the pole pieces and frame supply the path for the magnetic field. The commutator end head supports the brush holders and brushes that are needed to conduct the electricity from the revolving armature. A ball bearing in the commutator end head supports one end of the armature shaft. The drive end head includes a ball bearing which supports the drive end of the armature shaft. Both end heads have mounting lugs which are used to mount the complete generator. The armature consists of a soft iron core, a commutator and the windings which are wound in slots in the core and are connected to the commutator. The commutator consists of 51 copper wedges insulated from each other and from the armature shaft.

A centrifugal fan is combined with the drive pulley. This fan draws air in thru the holes in the commutator end head over the amature end field windings and expels the air thru the holes in the drive end head. This ventilation allows a high safe output without the danger of overheating the generator.

When the generator armature is turned the armature windings cut thru the magnetic field. This generates current which is carried away by the commutator and brushes. The field excitation current is taken from the armature by one of the brushes. The amount of field current and therefore the generator output is controlled by the regulator.

(d). Current-Voltage Regulator.— (Refer to Fig. 27, Page 33.) The current-voltage regulator is composed of three units, each with a separate function to perform. These three units are the circuit breaker unit, the voltage regulator unit and the current limiting regulator unit.

1. Circuit Breaker.— The function of a circuit breaker in automotive type electrical equipment is to automatically close and open the circuit between the generator and storage battery.

It consists of an electromagnet and two sets of contacts. These two sets of contacts operate simultaneously and are connected in parallel to reduce voltage loss. They are mounted with one contact of each pair on a stationary bracket, and the others on a movable armature which is controlled by the electromagnet. The contacts are mounted on spring arms so that as the contacts open and close a slight wiping action is produced.

The electromagnet of the circuit breaker has two windings, one the shunt coil which is connected across the generator output like a voltmeter and the other a series coil connected in series with the generator output like an ammeter. These two coils are wound in the same direction so that when the generator is charging the battery, the magnetism of the series coil increases the total magnetism. When the battery discharges back thru the generator the magnetism of the series coil is reversed and the magnetism of the two coils is opposed. This results in a decreased pull on the armature and spring action opens the contacts.

The sequence of operation of the circuit breaker unit is as follows: when the generator is not running, the contacts are open. When the generator is started, the voltage builds up at the armature terminal and in the shunt coil and as soon as it reaches the value for which the circuit breaker is calibrated, there is sufficient magnetism created by the shunt coil to pull down the armature, closing the contacts which automatically connects the generator to the battery. With the contacts thus closed the current

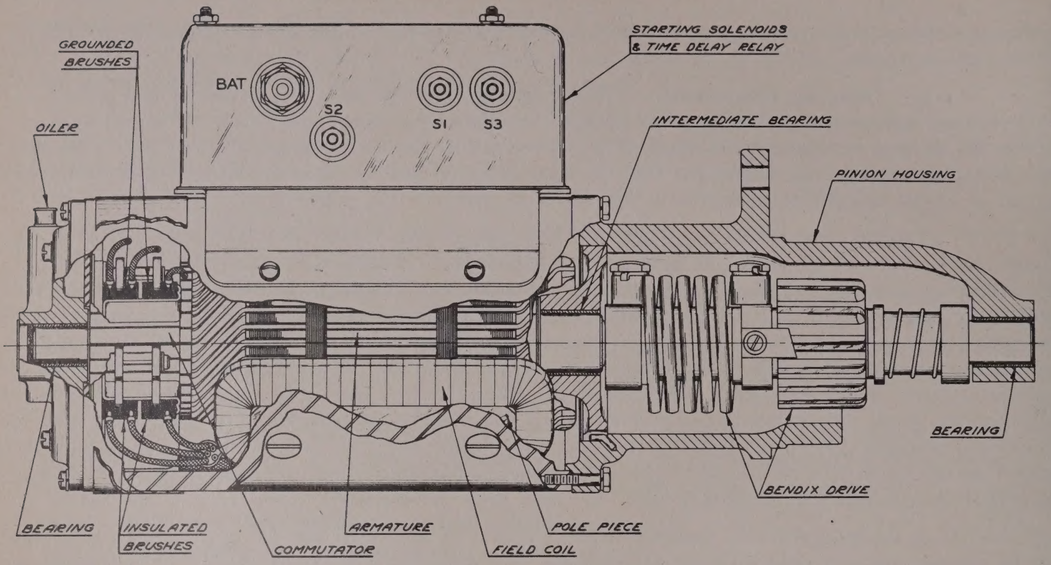
GROUNDED BRUSHES
OILER
BAT
S2
S1
S3
STARTING SOLENOIDS & TIME DELAY RELAY
INTERMEDIATE BEARING
PINION HOUSING
BEARING
BENDIX DRIVE
BEARING
INSULATED BRUSHES
COMMUTATOR
ARMATURE
FIELD COIL
POLE PIECE

Fig. 25 — Starting Motor

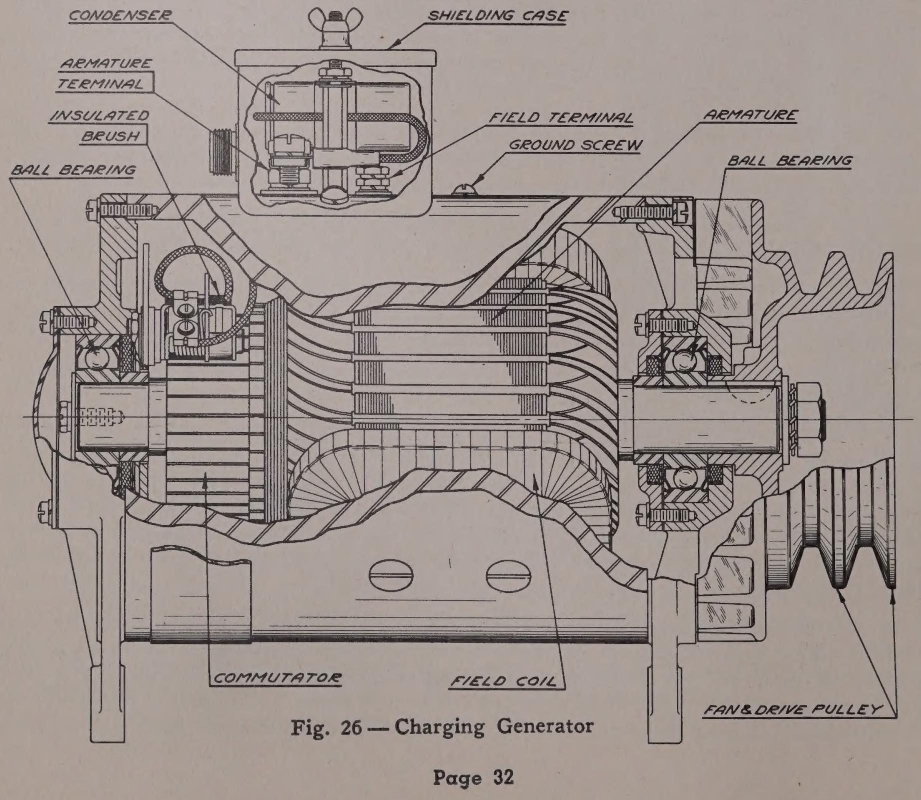
CONDENSER
SHIELDING CASE
ARMATURE TERMINAL
INSULATED BRUSH
BALL BEARING
FIELD TERMINAL
GROUND SCREW
ARMATURE
BALL BEARING
COMMUTATOR
FIELD COIL
FAN & DRIVE PULLEY

Fig. 26 — Charging Generator

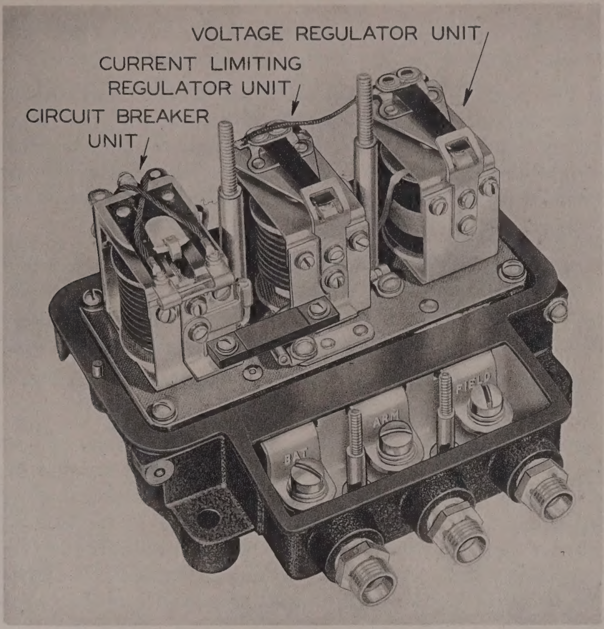

Fig. 27 — Current-Voltage Regulator

in the series coil is flowing from the generator to the battery or in the same direction as the current in the shunt coil, so that the pull on the armature is increased by the magnetism of the series coil.

When the engine is stopped and the generator loses speed, the voltage falls, and as soon as the generator voltage drops below the battery terminal voltage, the current flows from the battery to the generator, reversing the direction of the current in the series coil so that the magnetism created by the series coil opposes and reduces the magnetism of the shunt coil. This reduces the pull on the armature to a point where spring action opens the contacts.

2. Voltage Regulator.— The function of the voltage regulator is to hold the generated voltage at a predetermined value as long as the circuit values allow the voltage to build up to the operating voltage.

The electromagnet of the voltage regulator unit has a winding of many turns of fine wire and is connected across the charging circuit so that the system voltage controls the amount of magnetism.

The contacts of the voltage regulator unit are connected in the generator field circuit so that the field circuit is completed thru the contacts when they are closed and thru a combination of resistors when the contacts are opened.

When the voltage rises to a predetermined value there is sufficient magnetism created by the regulator winding to pull the armature down. This opens the contacts and inserts resistance in the field circuit of the generator thus reducing the field current. The generated voltage immediately drops which reduces the pull on the armature to the point where the spring closes the contacts. The output again rises and the cycle is repeated.

These cycles occur at high enough frequencies to hold the generated voltage at a constant value and will continue as long as the voltage of the circuit is high enough to keep the voltage regulator unit in operation. With the addition of a current load great enough to lower the battery voltage below the operating voltage of the unit, the contacts will remain closed and the generator will maintain a charging rate as limited by its speed or the current limiting regulator.

Due to the effect of heat on the operating characteristics of regulator windings it is necessary to compensate for the changes in coil resistance when the regulator is operating under varying temperature conditions. This is accomplished thru the use of a nickel iron magnetic by-pass on the voltage regulator unit. This shunt by-passes some of the magnet flux when the unit is cold and allows most of the flux to act on the armature when the unit is hot. Thus when the coil is hot and not as efficient the magnetic shunt reduces the amount of flux needed to vibrate the armature.

The compensation is usually more than enough to offset the changes in regulator coil resistance due to heat. The excess compensation allows the regulator to operate at higher voltages under cold operating conditions than under hot conditions. This is necessary as it requires a higher voltage to charge a battery with its internal resistance increased by low temperatures.

3. Current-Limiting Regulator.— The function of the current-limiting regulator is to limit the output of the generator to its maximum safe output.

The electromagnet of the current regulator unit consists of a winding of heavy wire that is connected in series with the generator output. When the generator output reaches a predetermined value the current in the winding produces enough magnetism to overcome the spring tension and pull the armature down. This opens the contacts and inserts resistance in the field circuit of the generator. With the field current reduced by the resistance, the generator output falls and there is no longer enough magnetism to hold the contacts open. As soon as the spring closes the contacts, the output rises and the cycle is repeated. These cycles occur at high enough frequencies to limit the output to a minimum fluctuation.

(e). Starting Batteries.— Four 6-volt, 3-cell, batteries connected in series, are used to supply the energy for cranking the engine. These batteries are furnished dry-charged with the electrolyte packed separately in glass containers. Each unit of 3 cells is of the conventional rubber container construction as shown in Fig. 28.

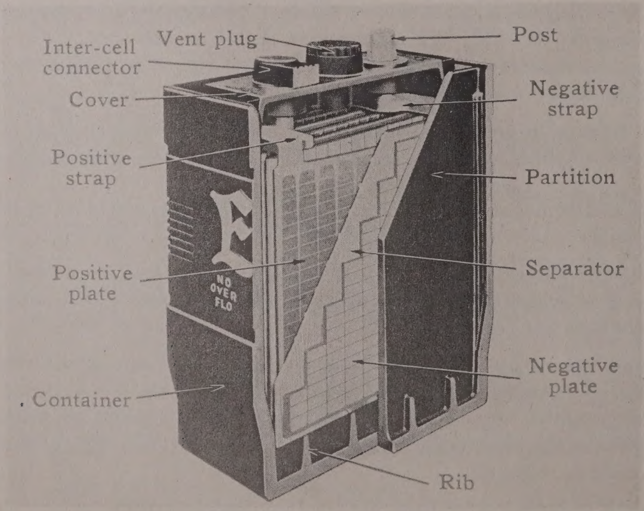

Fig. 28 — Starting Battery

(15). Hand Starting System.— A method for starting the engine by hand is provided by means of a hand crank mounted on the radiator support directly under the radiator. A "dog" or ratchet is mounted on the inner end of the hand crank which engages a pin thru a cast iron hub mounted on the end of the crankshaft. This "dog" automatically comes free when the engine starts. Compression release is accomplished by means of cam levers mounted in the valve cover. These cam levers hold the inlet valves open until a maximum speed is reached when cranking by hand. The compression releases are manually operated for both opening and closing.

(16). Alarm and Protective System.— The following equipment makes up the alarm and protective system on the engine instrument panel:

(a). One alarm bell to sound alarm in case of engine shut down.

(b). One toggle switch to switch the alarm system "ON" or "OFF."

(c). One green jewel pilot light to give a visual indication of the position of the toggle switch.

(d). Two binding posts to make the shunt-trip connections from the switchboard.

(e). The safety control, which shuts off the engine fuel oil in the event of high cooling water temperature, or low lubricating oil pressure, also operates an alarm switch. The engine alarm and protective system is connected to this alarm switch. When the alarm switch closes, it completes the electric circuit through the toggle switch, and causes the battery to ring the alarm bell. In addition, a parallel circuit from the bell energizes the shunt-trip circuit on the switchboard, and trips the circuit breaker on the switchboard.

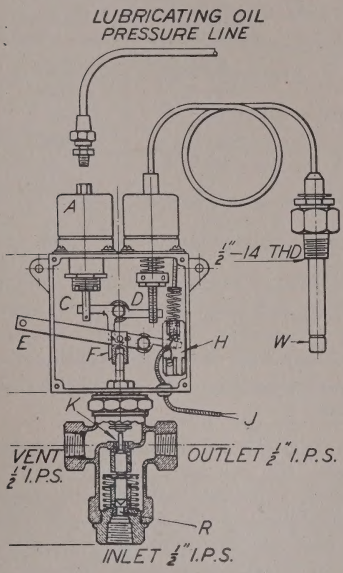

Fig. 29 — Alarm and Protective System

The safety control is a simple non-electric, self-operated device. In normal engine operation the control mechanism is in position shown by Fig. 29. A simple trigger arrangement (F) supports spring loaded lever (E) which operates the valve. Lubricating oil pressure on (A) holds plunger (C) in downward position. Normal operating temperature on thermostat (W) holds plunger (D) in UP position. With failure of lubricating oil supply, the pressure at (A) falls off allowing plunger (C) to return to the UP position to operate trigger (F). This releases latch (E) to operate the valve. Bottom port (R) is closed to the fuel supply and top port (K) is opened, to allow fuel in the injector line to drain back — consequently, the engine is immediately stopped. At the same time lever (E) closes contacts on switch (H) to operate the alarm thru connection (J) to the toggle switch on the instrument panel. When normal conditions are restored, the control is manually reset by lifting lever (E). The latch or trigger will not engage until the trouble is rectified which caused the safety control to trip.

In like manner a rise in temperature on thermostat (W) above the safe point allows plunger (D) to move downward to operate trigger (F). In any case, either the pressure element or the thermostat will function independently of each other.

In the event of failure of, or damage to either the pressure element or the thermostat, the safety control will operate to stop the engine.

The fuel shut-off valve has sylphon bellows packless construction which eliminates friction and leakage.

2. GENERATING EQUIPMENT.—

a. General Description.—

(1). Rating.

(a). The generator (1) Fig. 30, and its exciter (28) have ratings as given in the accompanying table.

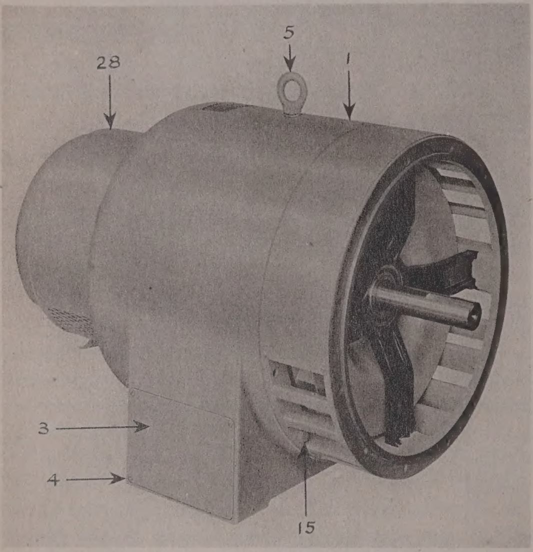

Fig. 30 — Synchronous Generator with Exciter

	Generator Model 12G565	Exciter Model 17G392
Type	ATI	BF
Frame	944-E	810
Kilowatts	15	1
Volts	208/120	125
Amperes	52	8
Phase	3	....
Cycles	60	....
RPM	1200	1200

(b). The generator has windings which produce 208 and 120 volts output simultaneously. However, under no conditions should the output be maintained continuously at a higher value than 52 amperes on the highest line.

(c). Under a continuous load of 15 kilowatts, the generator is guaranteed to have a temperature rise not exceeding 40 C (72 F) above the ambient temperature. Temperatures are measured by a thermometer placed on the hottest accessible portion of the windings.

(d). The generator is capable of operating for a two-hour period under a 25 per cent overload on the highest line, and may then be continuously operated at its rated load. During the overload period, the temperature rise of any winding will not exceed 55 C (99F).

(e). The shunt-wound exciter is capable of furnishing sufficient excitation to meet the generator requirements at rated load and overload conditions. The temperature rise of the exciter windings will not exceed 40 C (72 F) when operating within its rating.

(2). Electric Theory.—

(a). The generator (1) Fig. 30, with its exciter (28) transforms mechanical energy of the diesel engine into electric energy for operation of radio equipment, lights, motors, or heaters. This transformation may be explained as follows:

1. The diesel engine rotates the exciter armature and generator rotor assembly.

2. Residual magnetism in the exciter field poles sets up a magnetic flux which passes across the exciter air gap and into the exciter armature.

3. As the armature conductors pass the poles an alternating voltage is generated in the conductors.

4. Brushes on the commutator collect the generated current. The brushes and commutator are a mechanical rectifier which changes the alternating current generated in the armature conductors into direct current. This process is called commutation.

5. The connections are made so that a small portion of this direct current is diverted thru the exciter field coils to produce an increase in strength of the magnetic flux and in turn to generate a higher voltage until the requirements of the generator are met.

6. The larger portion of this direct current flows thru the generator-rotor windings by way of the generator brushes (20) Fig. 31, and the collector rings (11).

7. As the generator-rotor fields pass the conductors in the stator, an alternating voltage is generated in those conductors.

8. The value of generated voltage is proportional to the speed of the rotor and generator rotor current.

9. The amount of current varies according to characteristics of the external circuit.

(3). Mechanical Arrangement.—

(a). The generator has three main sub-assemblies, see Fig. 31.

1. Rotor assembly (6) Fig. 31, consists of the following parts:

a. Two bearings (14) Fig. 32, Page 38 which are pressed on the shaft.

b. One ventilating fan (10) which is pressed on the shaft.

c. Two collector rings (11) which are also pressed on the shaft.

d. Six field poles (7) with windings around them, all of which are attached to a spider which in turn is pressed on the shaft.

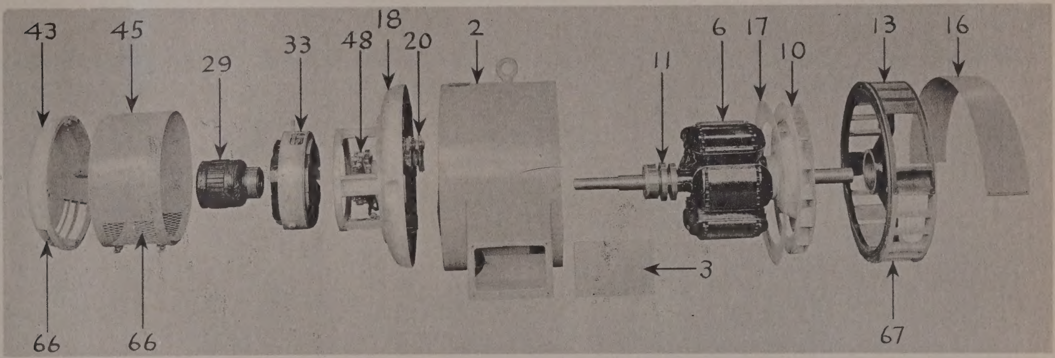

Fig. 31 — Exploded View of Generator and Exciter

2. Stator Assembly (2) Fig. 31 consists of the following parts:

a. A cast iron frame (60) Fig. 33, Page 38.

b. Slotted punchings (61) assembled and keyed to the frame.

c. Insulated windings (62) assembled in the slots and connected together.

3. Brush Rigging.—

The generator brush rigging (20) Fig. 31 consists of these parts:

1. Four brushes (20) Fig. 34, Page 38 and Fig. 35, Page 39.

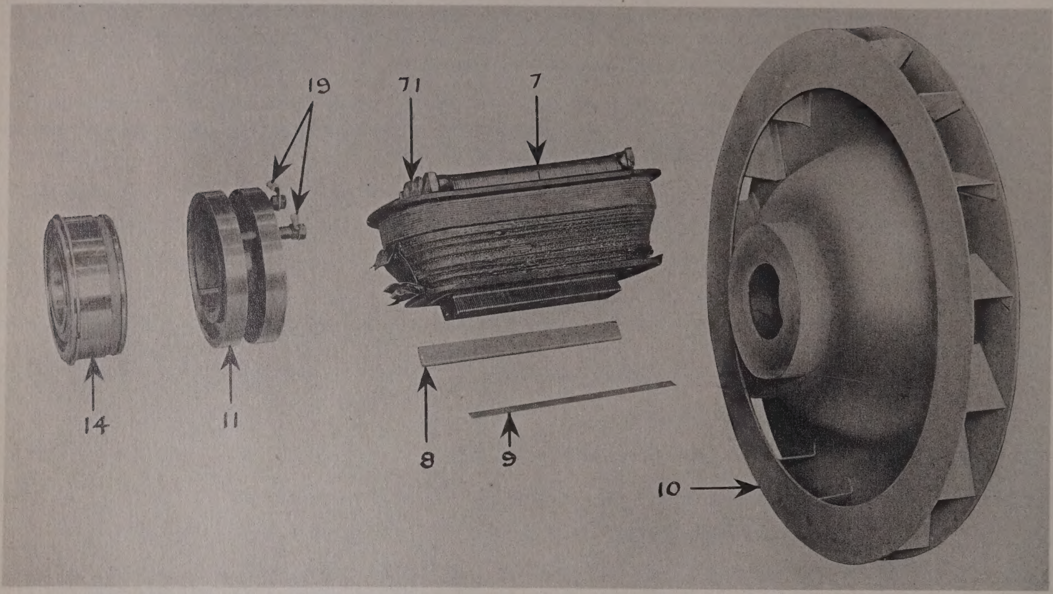
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Fig. 32 — Bearing, Collector Rings, Rotor Pole, Key, Shim and Fan of Generator

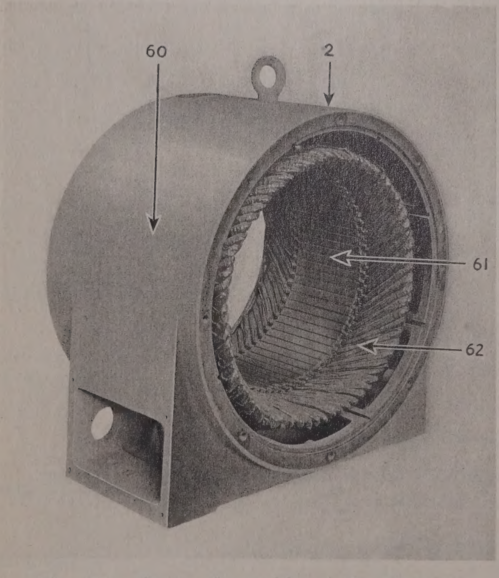


Fig. 33 — Stator Assembly of the Generator

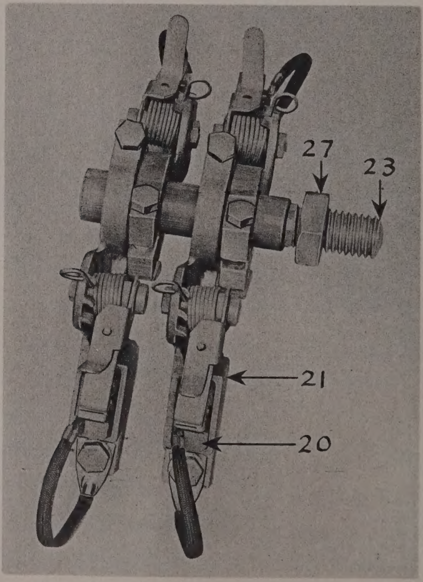


Fig. 34 — Generator Brush Rigging

2. Four brush holders (21).

3. One insulated stud (23) upon which the brush holders are mounted.

(b). A cast iron bearing bracket and adaptor (13) Fig. 31, Page 37 with a removable cover (16) is mounted on the generator frame-engine end.

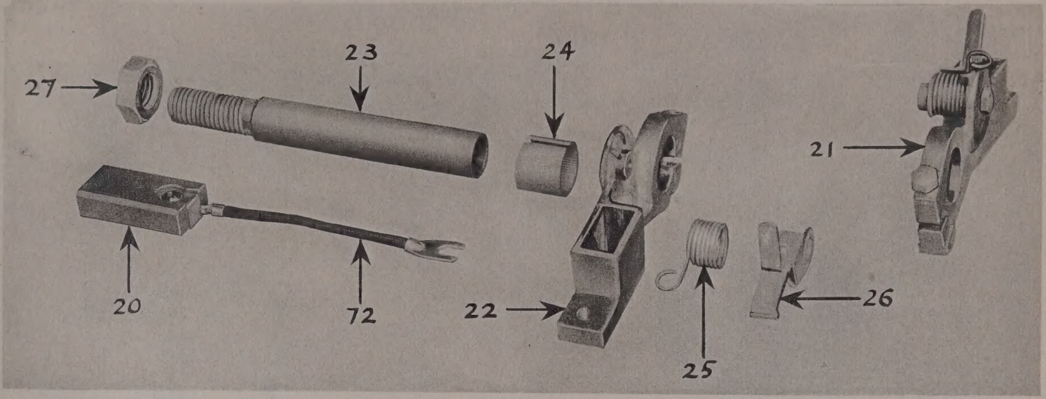


Fig. 35 — Exploded View of Generator Brush Holder Assembly

(c). A cast iron end shield and extension (18) Fig. 31, Page 37 with a removable cover (45) is mounted on the exciter end of the generator frame.

(d). The exciter is directly connected to the generator. The magnet frame assembly (33) Fig. 31, Page 37 is bolted to the generator end shield extension (18). The exciter armature (29) is pressed on an extension of the generator shaft and held in place by a cap screw in the end of the shaft.

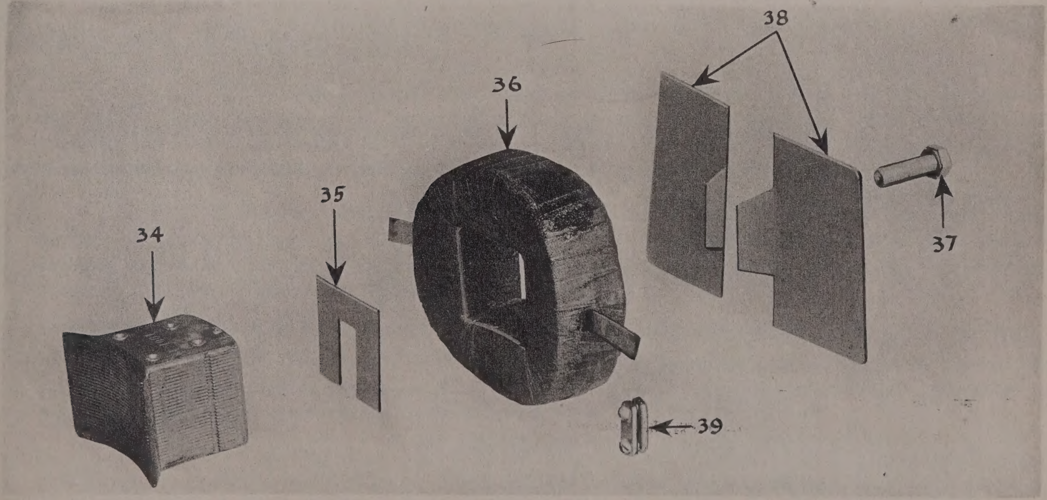


Fig. 36 — Exploded View of Exciter Main Field Coil and Pole

(e). The exciter consists of three main sub-assemblies.

1. Magnet frame assembly (33) Fig. 31, Page 37. This assembly consists of these parts:

a. One magnet ring (33) Fig. 31, Page 37.

b. Four laminated poles (34) Fig. 36, Page 39 bolted to the ring.

c. Four coils around the poles (36) Fig. 36, Page 39.

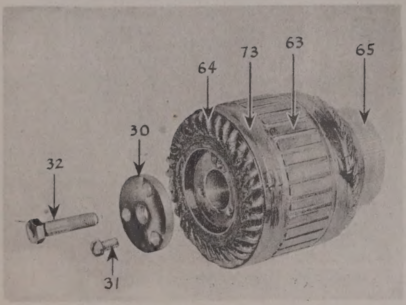


Fig. 37 — Exploded View of Exciter Rotor Assembly

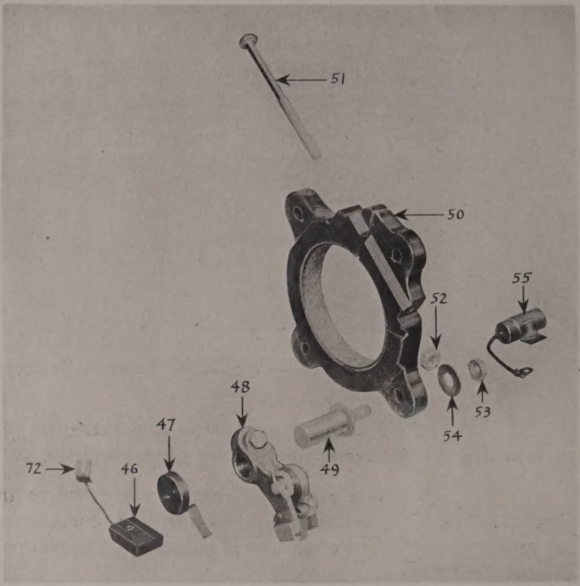


Fig. 38 — Exploded View of Exciter Brush Rigging

2. Armature (29) Fig. 31, Page 37. The armature consists of the following parts:

a. Slotted punchings (63) Fig. 37 held in place by end flanges pressed and keyed in place on a steel shell.

b. Coils in the slots (64) Fig. 37.

c. A commutator (65) Fig. 37 connected to the coils.

3. Brush Rigging (48) Fig. 31, Page 37. This assembly consists of these parts:

a. One brush yoke (50) Fig. 38.

b. One clamping bolt (51) Fig. 38 and nut (52).

c. Four brush holder studs (49) Fig. 38.

d. Four brush holders (48) Fig. 38.

e. Four brush assemblies (46) Fig. 38.

f. Ventilation of the generator and its exciter is of the axial type. A large centrifugal fan (10) Fig. 31, Page 37 mounted on the generator shaft near the engine end draws air thru the machine. Air inlets (66) are located along the lower half of the exciter wrap-around cover (45) and end shield (43). Air outlets (67) are located along the lower half of the end bearing bracket (13). The path of cooling air is as follows:

1. Thru inlet openings (66).

2. Around exciter armature (29).

3. Around exciter field poles and coils (33).

4. Into the generator thru openings in the end shield (18).

5. Between generator rotor coils (6) and between the generator frame and the outside of the stator laminations.

6. Thru blades of the fan (10).

7. Out thru the outlet openings (67).

b. Detailed Description.—

(1). Generator.—

(a). Rotor Assembly.—

1. The generator is equipped with two cartridge type ball bearings (14) Fig. 32, Page 38. They are packed and sealed by the bearing manufacturer with sufficient grease to give approximately 8000 hours or two years service under normal operating conditions. Each bearing is furnished with two metal seals (68) Fig. 139, Page 138 and snap rings (69) to hold the seals in place. The seals keep the lubricant within the bearing as well as keep foreign matter from gaining access to the bearing housing. Each bearing is furnished with one shoulder ring (70) which limits axial movement of the rotor assembly.

2. The ventilating fan (10) Fig. 39, Page 42 is of all welded steel plate construction. The body of the fan is welded to a large hub which is pressed on and keyed to the shaft.

3. The rotor spider (6) is made of high quality steel punchings securely riveted together and pressed and keyed on to the shaft.

4. Pole pieces (7) are made of selected steel laminations riveted together under pressure and provided with dovetails which are keyed to the rotor spider. Pole pieces are wrapped with layers of prepared and treated insulating material. Large insulating collars support the windings and insulate them from the pole tip and spider.

5. The field coils (62) Fig. 33, Page 38 of double cotton-covered wire are wound directly on the pre-insulated pole pieces. The wires in each layer of the coil are well saturated with an insulating-bonding compound which binds the wires solidly together. After baking, the coils are dipped in a moisture resistant varnish and baked again to set the varnish.

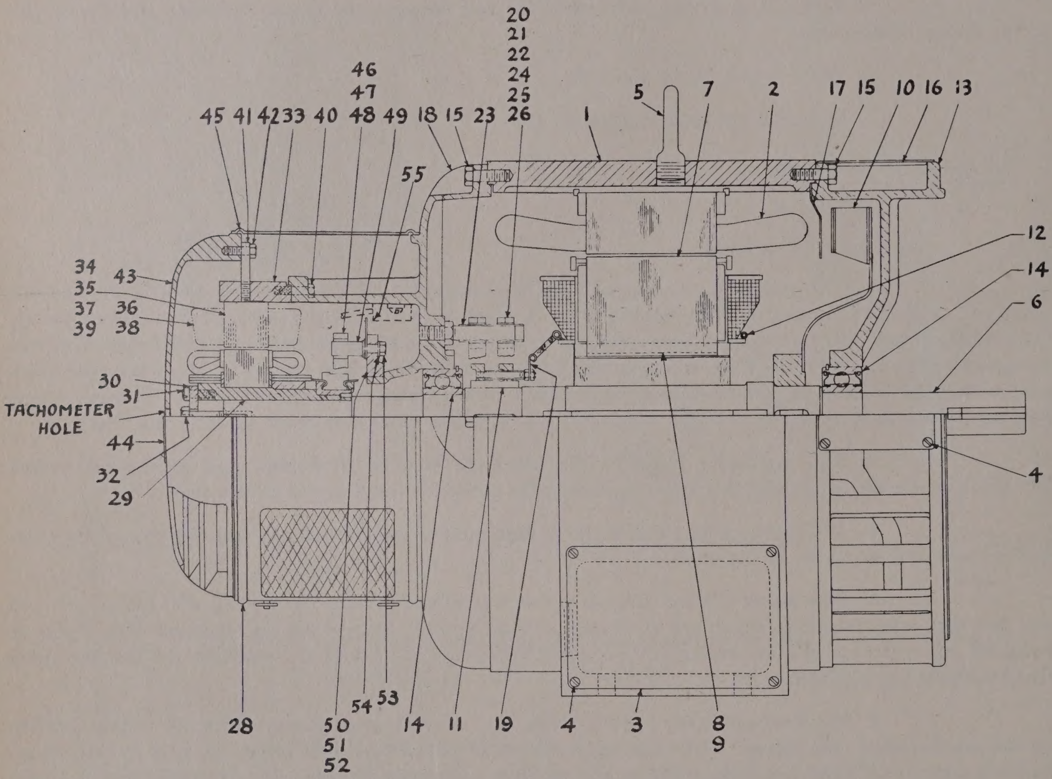
6. Each pole is furnished with a copper amortisseur winding (71) Fig. 32, Page 38 located in the pole tips. Bars of these windings are fitted into holes in the copper end rings and are silver-soldered at red heat, making permanent alloy joints. Amortisseur windings improve the generators operation when connected in parallel with other units.

7. Collector rings (11) Fig. 39, Page 42 are shrunk on an insulated shell which is pressed on the generator shaft. The shell is made of a laminated-phenolic plastic. The rings are made of centrifugally cast bronze, machined to size after assembly on the shaft.

(b). Stator Assembly.—

1. Stator laminations (61) Fig. 33, Page 38 are made of high-grade non-aging silicon steel. Heavy end flanges (keyed to the stator frame) hold the laminated punchings in place under pressure. Laminations are assembled in dovetailed slots machined in the stator-reinforcing ribs, thus assuring rigid support.

2. The stator winding (62) Fig. 33, Page 38 is of the random wound or mush type, thoroughly insulated after insertion into the stator slots. All coils are insulated from the punchings by slot tubes. Hard maple wedges hold coils tightly in the slots. After winding, the stator is thoroughly impregnated with a varnish; which is resistant to acid, oil and moisture.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31
TACHOMETER HOLE
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Fig. 39 — Sectional Outline of Generator and Exciter

(c). Brush Rigging.—

1. The brush rigging Fig. 34, Page 38 is held to the end shield by an insulated stud (23). A jam-nut (27) locks the stud in position. Brush holders are mounted on the stud, around which are placed two brass ferrules (24) Fig. 35, Page 39 with corrugated surfaces. Brush holders are clamped around the ferrules, and maintain their position even under considerable vibration of the generator. Note that two brush holders are clamped around each ferrule.

2. Brush holders (21) Fig. 35, Page 39 are made of die cast brass. Each holder has a lever assembly (26) which is under spring pressure and which rides a metallic top on the carbon brush. Brush pressure may be adjusted by three possible spring positions.

3. Each brush is provided with an insulated copper pigtail (72) Fig. 35, Page 39, the end of which is connected to the brush holder.

(2). Exciter.—

(a). Armature.—

1. The spider is a machined-steel shell on which silicon steel laminations (63) Fig. 37, Page 40 are stacked under pressure. An end flange pressed and keyed in place holds the laminations tightly in position.

2. The commutator (65) is of the riveted type, built of copper bars on its own shell. Mica insulates the bars from each other and from the shaft. The complete commutator is pressed on to the spider and keyed in place.

3. The coils (64) (wound of heavy formex-insulated wire) are taped, varnish impregnated, baked, and then assembled in the armature slots with heavy paper slot insulation. Coil leads are soldered to the commutator risers. Binding wire (73) is wound tightly around the assembly at each end of the stacking to hold the coils securely in their slots. The entire assembly is then given a final varnish treatment for protection against moisture, dirt, and weak acid.

(b). Magnet Frame Assembly.—

1. The magnet frame (33) Fig. 39, Page 42 is a steel ring which completes the magnetic circuit and supports field coils and pole pieces.

2. Pole pieces (34) Fig. 36, Page 39 consist of high-grade, non-aging silicon sheet steel punchings securely riveted together.

3. The coils (36) are of heavy formex-insulated wire wound on a varnish treated paper spool. Coils are completely covered with cotton tape and thoroughly impregnated with varnish to provide additional resistance to the entrance of moisture.

4. The coils are slipped over pole pieces (34) which are bolted to the magnet ring (33) Fig. 31, Page 37.

(c). Brush Rigging.—

1. The brush yoke (50) Fig. 38, Page 40 (moulded of a cloth-base phenolic plastic) performs the dual function of supporting the brush holder studs (49) and insulating them from each other as well as from the generator end shield.

2. The steel brush holder studs support the cast-brass brush holders (48). The brush holder supports the carbon brushes (46) which are connected electrically to their holders by copper pigtails (72). Brushes are held against the commutator by a coiled spring which may be adjusted to three possible positions by its lever.

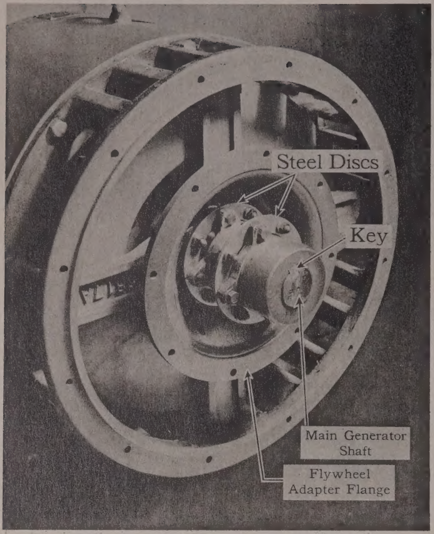


Fig. 40 — Flexible Coupling

3. FLEXIBLE COUPLING.— The flexible coupling is an assembly of parts mounted on, and keyed to the main generator shaft. It is bolted to the engine flywheel by means of an adapter flange. The coupling transmits the power developed by the engine to the main generator.

This coupling is of the all-metal double engagement type with stainless steel discs. The double engagement allows for angular misalignment as well as parallel misalignment and free end float.

4. SWITCHBOARD.— The switchboard provides the necessary instruments and equipment to properly connect, operate, and control the generator and exciter of the engine-generator unit. The switchboard is a steel panel with self-supporting angle iron frame. Holes in the base are provided for mounting the switchboard to the floor. Maximum physical dimensions are as follows: 76″ high, 24″ wide, and 30″ deep. The net weight is 200 pounds.

The panel includes the following:

a. One alternating current ammeter with scale 0-75 for indicating the current being supplied to the load.

b. One three-position ammeter switch for switching the ammeter to each line of the three-phase load.

c. One alternating current voltmeter with scale 0-300 for indicating the line voltage.

d. One three-position voltmeter switch for switching the voltmeter to each three-phase line.

e. One frequency meter for indicating the frequency in cycles per second the generator is producing This instrument has a range from 58 to 62 cycles.

f. Four synchronizing lights which are used to indicate when the generators are in step so that they can operate in parallel.

g. One circuit breaker to switch the load "ON" or "OFF." This breaker is equipped with a shunt trip device which is connected to the engine protective and alarm system. This shunt trip device will trip off the breaker in case the engine shuts down for any reason.

The circuit breaker is manually operated and is equipped with a Thermal-Magnetic trip unit. The adjustment of the Thermal part of this unit is set by the manufacturer of the breaker. The adjustment for the Magnetic part of the trip unit will be found on the bottom end of the breaker. It is set at 350 amps. at the factory, and should not be changed. The Magnetic trip will instantly trip the breaker in case of short or extreme overload on the line.

The circuit breaker is equipped also with a shunt trip attachment. The shunt trip attachment is connected to the engine alarm system, and it will trip the breaker at the same time the alarm bell rings on the engine instrument panel.

h. One voltage regulator which controls the amount of current the exciter supplies to the main generator. The generator, in turn controls the line voltage.

The voltage regulator is comprised of but one essential element, a voltage-sensitive relay. There is but one moving part, a light vibrating armature. The armature is designed to follow the rapid variation in magnetic flux in the coil. The coil has a laminated fixed iron core which is magnetized to maximum strength at each half-cycle of A.C. current in the coil. The core, when magnetized, attracts an iron button on the vibrator and causes the vibrator to travel from a position of repose toward the magnetized core.

Since the magnetic flux in the core depends upon the current in the coil, and the current in the coil depends upon the voltage across the coil, it is readily seen that the flux variations can be used to control the voltage.

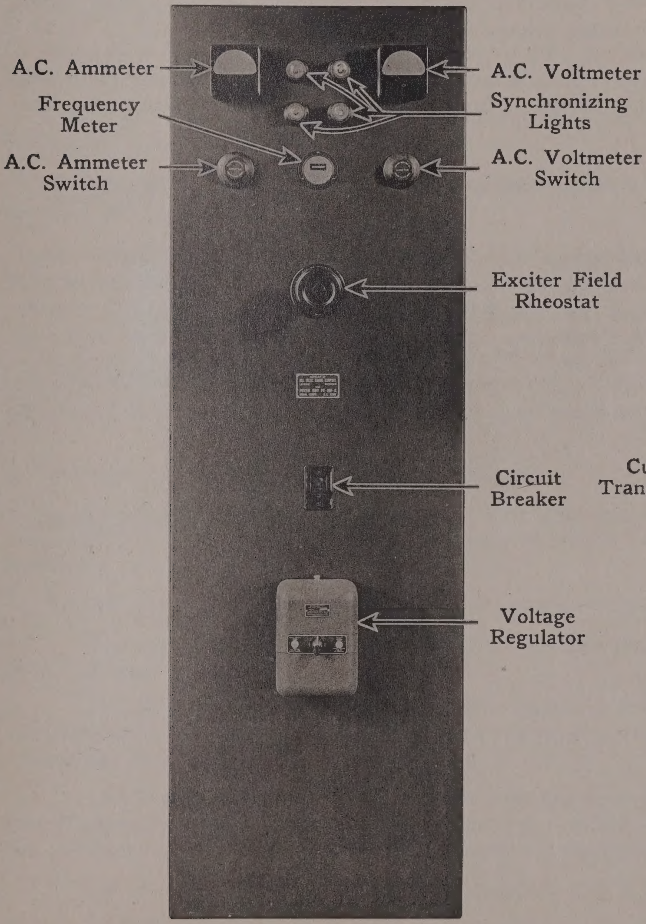

A.C. Ammeter
Frequency Meter
A.C. Ammeter Switch
A.C. Voltmeter
Synchronizing Lights
A.C. Voltmeter Switch
Exciter Field Rheostat
Circuit Breaker
Voltage Regulator

Fig. 41 — Switchboard Front View

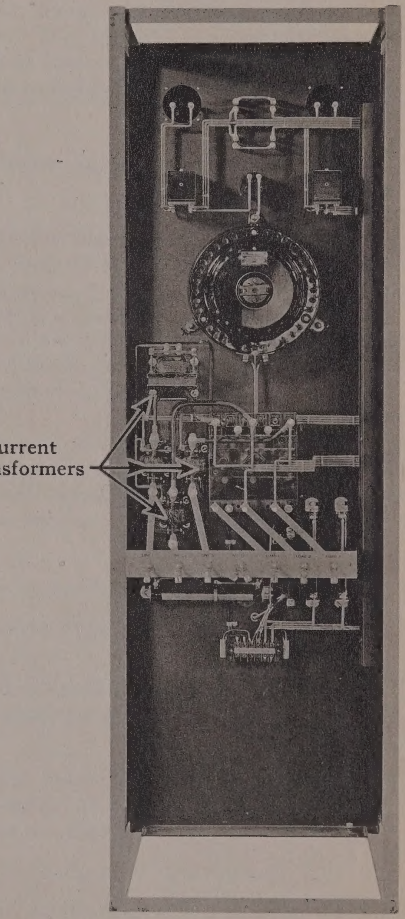

Current Transformers

Fig. 42 — Switchboard Rear View

A contact is placed on the upper side of the vibrator. This contact engages a second contact resiliently mounted above the vibrator contact. The maximum pressure of the vibrator contact against the upper contact occurs when the coil voltage is zero. Under proper operation and with normal A.C. volts, the contacts open slightly each time the A.C. voltage cycle reaches positive or negative maximum and closes each time the voltage cycle goes thru zero.

The upper contact being resiliently mounted and having an initial tension, it is seen that the lower the average voltage on the coil, the closer to the upper contact the vibrator will operate. The ratio of the time of vibrator contact engagement with the upper contact to the time which the contacts are open gives the average resistance to current flow thru the contacts.

The contacts operate in shunt with the exciter field rheostat. The exciter field rheostat indirectly controls the A.C. voltage. Increasing the resistance lowers the voltage, and decreasing the resistance increases the A.C. voltage. If the contacts of the regulator are closed for a longer period during each A.C. cycle than they are open, the exciter voltage should increase. If the contacts are open for a longer period of time during the cycle than closed, the exciter voltage should decrease.

The spring which pulls upward on the vibrator, offsets the magnetic pull of the coil, so that a drop in A.C. voltage results in a weakening of the magnetic flux, and consequent greater contact closing force by the spring.

i. One exciter field rheostat which is used to manually control the voltage when the regulator is not used.

j. Four current transformers mounted on the back of the panel are used in the alternating current circuit. The function of three of these transformers is to reduce the current according to a definite ratio in order to allow this current to be metered. The remaining current transformer is connected in the voltage regulator circuit. The function of this transformer is to prevent cross current between generators being operated in parallel.

B. INSTRUCTIONS FOR INSTALLATION

1. UNCRATING. —

a. Engine-Generator Set.— First remove the metal box stripping and remove the nails on both sides and ends of the top. The top may now be lifted off.

Detach the packing list which is contained in an envelope tied to the fuel control rack on the right side of the engine.

Remove the spare parts box, muffler and flexible exhaust hose which is fastened to the platform over the main generator.

Next remove the coil of tubing fastened to the left side of the crate next to the engine. The tubing fittings and fuel connection diagram are in a small cloth bag tied to the coil of tubing. The tubing and fittings are used to connect the fuel tank to the engine. This cloth bag also contains 16 self-threading screws for attaching the canvas duct to the front radiator guard.

The platform over the generator, the 2″ x 4″ brace across the front end of the engine and both ends of the crate, may now be removed.

Remove the steel battery rack fastened back of the generator. Take off the 2″ x 4″ brace across the top of the engine and remove both sides of the crate.

The engine-generator unit can now be lifted from the bottom of the crate by removing the four bolts holding the bottom of the crate to the steel subbase.

b. Switchboard.— Stand the switchboard crate on end and remove the metal stripping. Remove the front and back from the crate.

If the installation is temporary, all connections and adjustments can be made and the switchboard operated without removing the balance of the crate. This provides protection for the switchboard.

If the installation is permanent, however, the sides, top and bottom must be removed.

c. Batteries and Electrolyte.— One box of batteries and two boxes of electrolyte are shipped with each unit. The batteries may be removed from the box at any time during the installation, but the electrolyte should be left boxed until the batteries are installed in a permanent position.

2. PREPARING AND PLACING UNIT ON FOUNDATION. —

a. Mounting Unit on Concrete Floor.— If the generator unit is to be installed in a building with a substantial concrete floor it will not be necessary to remove a section of the floor and build a separate foundation on which to mount the generator unit.

The generator unit can be fastened to the floor in the following manner:

(1). Place the unit in the desired position and mark the floor thru the holes in the lower flange of the subbase.

(2). Remove the unit and with a chisel or suitable drill, make holes in the floor large enough to accommodate the head of a 5/8″ bolt and about 7½″ deep. Cut a channel outward from each hole about 3″ long and 1″ deep.

(3). Place a 5/8″ x 8″ bolt in each hole with the bolt head down, then lower the unit onto the floor allowing the bolts to extend thru the holes in the lower flange of the subbase. Place a nut on each bolt and turn each nut down until the end of the bolt is flush with the top of the nut.

(4). Pour molten lead into the channels which lead to the holes until they are full.

CAUTION: Make sure there is no liquid of any kind in the hole before pouring the lead, because when hot lead comes in contact with a liquid an explosion may take place.

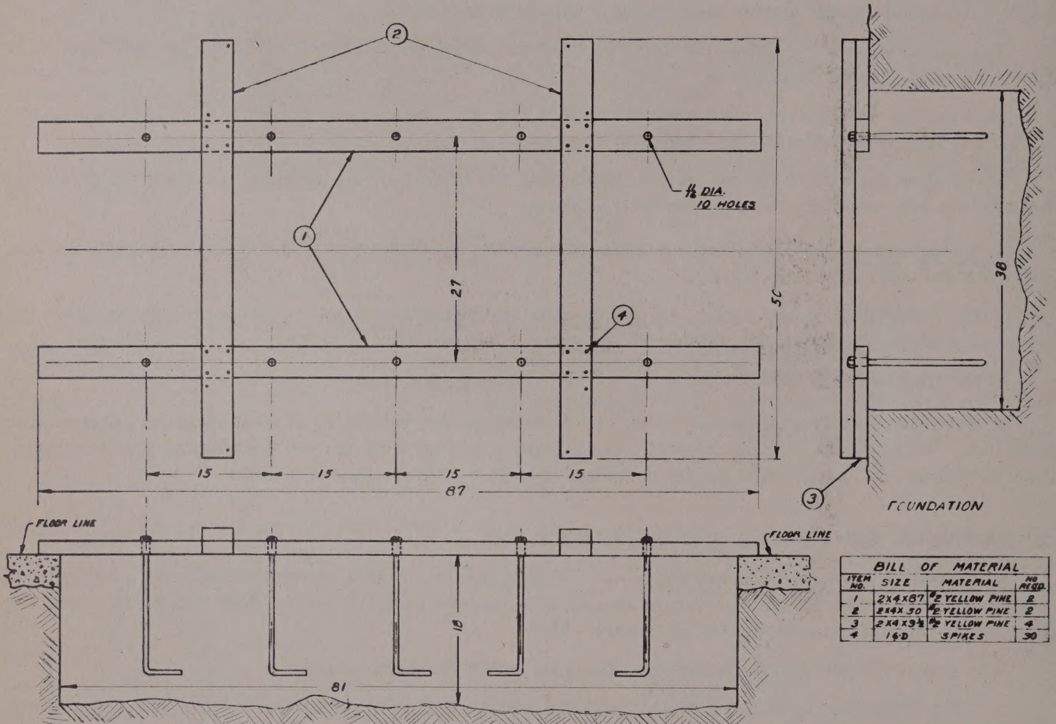
When the molten lead is poured, it is necessary to continue pouring until the hole is completely filled, otherwise a break will occur in the lead where the pouring was stopped.

(5). After the lead has cooled for about 30 minutes, the nuts may be tightened down.

b. Mounting Unit on Prepared Foundation.— The size of the foundation depends upon the type of soil where generator unit is installed. The following paragraphs describe a suggested foundation for average soil conditions.

(1). Making the Foundation. —

(a). Dig a hole approximately 81 inches long, 38 inches wide and 18 inches deep.



BILL OF MATERIAL			
ITEM NO.	SIZE	MATERIAL	NO REQD.
1	2X4X87	#2 YELLOW PINE	2
2	2X4X 50	#2 YELLOW PINE	2
3	2X4X9½	#2 YELLOW PINE	4
4	16·D	SPIKES	30

Fig. 43 — Foundation Template

(b). Make a wood template as shown in Fig. 43.

(c). Make 10, ⅝″ anchor bolts 24 inches long. Thread 3 inches of one end with ⅝″ x 11″ U.S.S. threads. Bend 4 inches of the other end at a 90° angle.

(d). Mix approximately 30 cu. ft. of concrete using 1 part of cement to 4 parts of coarse gravel and sharp sand. Thoroughly mix the above mixture then mix in enough water to make a heavy liquid.

(e). Place the anchor bolts in the template and lay the template over the hole.

Tamp the concrete mixture in the foundation hole and level it off to the lower edge of the template.

(f). Allow the concrete to set until it is thoroughly dry before removing the template.

(2). Placing Unit on Foundation. —

(a). Place a nut on each foundation bolt and turn it down as close to the foundation as possible using a wrench. Place an iron washer on top of each nut.

(b). Lower the unit onto the foundation bolts so that it rests on the washers and is supported by the nuts.

(c). Using an open end wrench on the nuts as a jack, adjust all the nuts to support the base equally and level.

(d.) Place a second iron washer and nut on each foundation bolt and pull down tight. See Fig. 44.

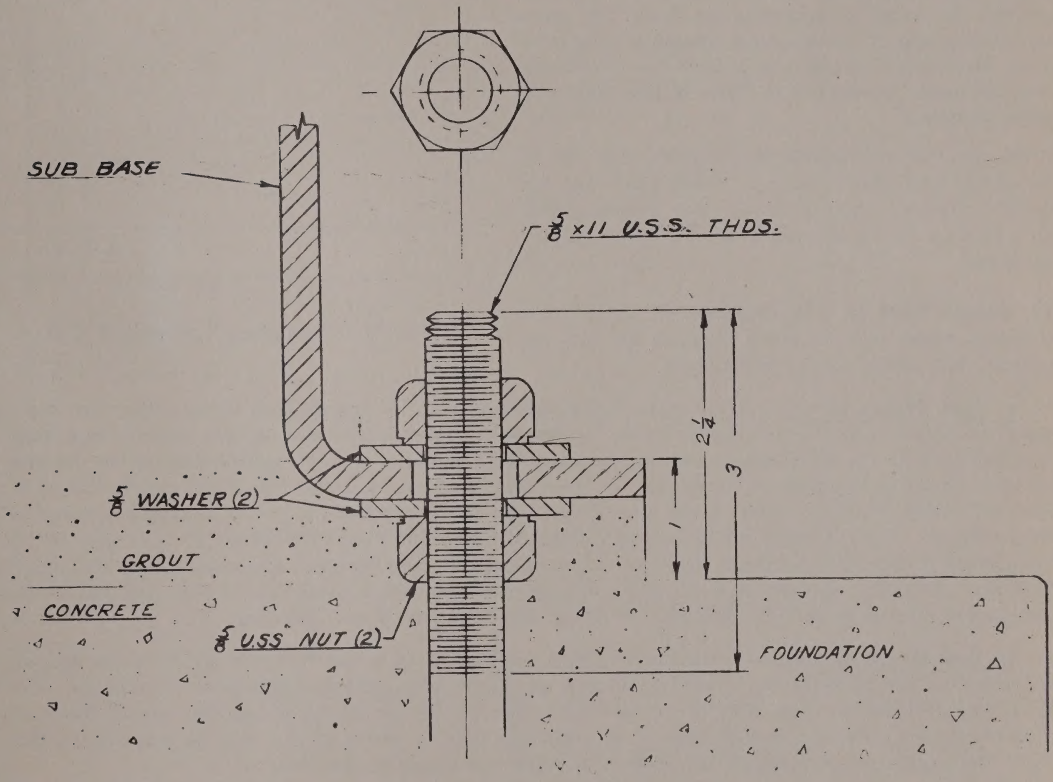


Fig. 44 — Foundation Detail

(3). Grouting In. —

(a). Make a wood frame around the lower flange of the subbase.

(b). Make a grout mixture (about 4 cu. ft.) of 1 part cement to 1 part of sharp sand and add enough water to give a thick liquid.

(c). Pour the mixture inside of the steel subbase and tamp under the subbase flange with a flat wood paddle.

(d). Allow the grout to dry thoroughly before removing the wood frame from around the subbase.

3. SETTING UP THE SWITCHBOARD.— The switchboard should be mounted in a location that is as free from vibration, moisture, dust and as accessible from all sides as possible. If space is available, mount panel so it can be seen while making adjustments on the engine. When installing two units which will be operated in parallel, mount their panels side by side to facilitate connections and adjustments. The panels can then be bolted or lagged to the floor. The most satisfactory way of locating the mounting bolts is to place the panel in position, and mark the foundation thru the holes provided in the base of the panel and angle supports.

If the panel is not immediately available, use Fig. 45 for mounting dimensions. It is essential that the panels be fastened securely to the floor, however, they do not need to be absolutely level for satisfactory operation.

4. CONNECTION OF THE UNIT.— When the unit is bolted down, you are ready to make the fuel oil, exhaust, air, and electrical connections.

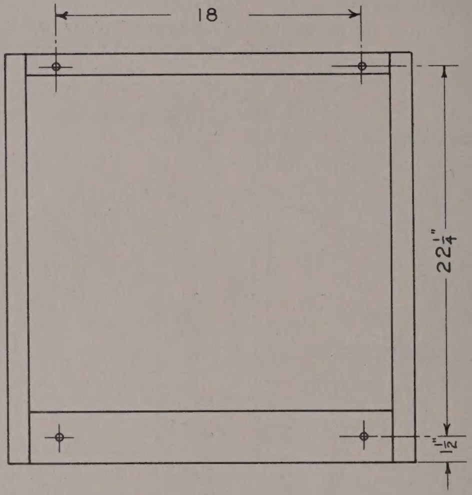


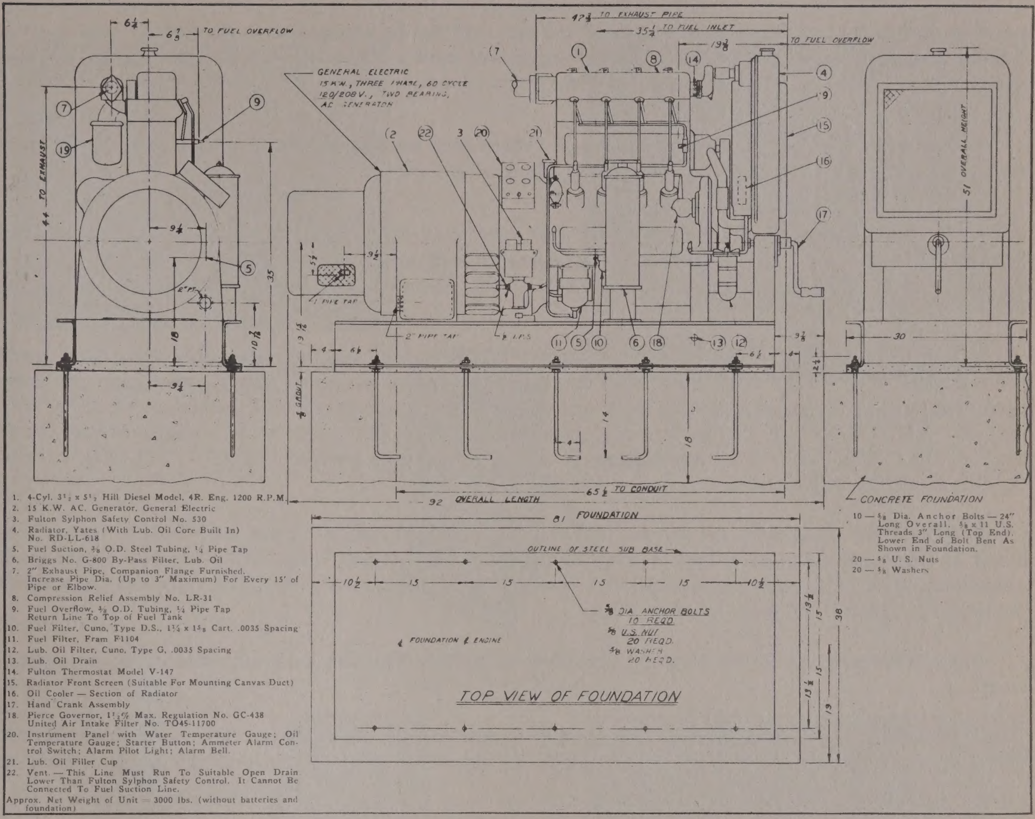
Fig. 45 — Switchboard Mounting Plan

a. Fuel Supply Line.— Connect the fuel supply line from the fuel oil tank to the engine fuel inlet using the copper tubing and fittings provided. Under no circumstances reduce the size of the tubing from that indicated on the installation plan Fig. 46, Page 51. The end of the fuel suction line within the fuel oil tank should be at a point 2 inches or more from the bottom of the tank. Use a fuel supply line of at least ½" outside diameter tubing if the fuel oil tank is more than 15 feet from the fuel supply connection on the engine. The bottom of the fuel oil tank should not be more than 8 feet below the fuel inlet of the fuel transfer pump. If it is more than 8 feet, difficulty may be experienced in properly feeding the engine with fuel. Although not absolutely necessary, it is advisable to have a check valve at the tank end of the fuel suction line to prevent the line from draining when the unit is not operating.

b. Fuel Overflow Line.— The fuel overflow line returns all excess fuel from the injection nozzles and injection pumps to the top of the fuel oil tank and helps relieve the fuel system of included air. Use the tubing provided for connecting the fuel overflow line. Do not use tubing of a smaller outside diameter than indicated on the installation plan. It is important that no valves of any kind be installed on this line. The engine would probably run away if a valve was closed in this line.

Connect the vent on the safety control to a suitable drain.

c. Exhaust Connections.— Exhaust connections should now be made by attaching the flexible tubing provided to the engine exhaust outlet. The silencer is attached to this flexible tubing and a tail pipe run from the silencer to the atmosphere. Care should be taken to brace the silencer in its hanging


6¼
6⅞ TO FUEL OVERFLOW
44 TO EXHAUST
9¼
35
2" PT.
18
10⅞
9¼
GENERAL ELECTRIC
15 K.W., THREE PHASE, 60 CYCLE
120/208 V., TWO BEARING,
AC GENERATOR
42¾ TO EXHAUST PIPE
35¼ TO FUEL INLET
19⅜ TO FUEL OVERFLOW
1 PIPE TAP
2" PIPE TAP
9½
4
6½
¾ GROUT
14
18
6½
9⅜
12¼
51 OVERALL HEIGHT
30
65½ TO CONDUIT
92 OVERALL LENGTH
CONCRETE FOUNDATION
81 FOUNDATION
OUTLINE OF STEEL SUB BASE
10½
15
15
15
15
10½
⅝ DIA ANCHOR BOLTS
10 REQD.
⅝ U.S. NUT
20 REQD.
⅝ WASHER
20 REQD.
℄ FOUNDATION ℄ ENGINE
TOP VIEW OF FOUNDATION
13½
15
38
15
13½
19

1. 4-Cyl. 3½ x 5½ Hill Diesel Model, 4R. Eng. 1200 R.P.M.
2. 15 K.W. AC. Generator, General Electric
3. Fulton Sylphon Safety Control No. 530
4. Radiator, Yates (With Lub. Oil Core Built In) No. RD-LL-618
5. Fuel Suction, ⅜ O.D. Steel Tubing, ¼ Pipe Tap
6. Briggs No. G-800 By-Pass Filter, Lub. Oil
7. 2" Exhaust Pipe, Companion Flange Furnished. Increase Pipe Dia. (Up to 3" Maximum) For Every 15' of Pipe or Elbow.
8. Compression Relief Assembly No. LR-31
9. Fuel Overflow, ⅜ O.D. Tubing, ¼ Pipe Tap Return Line To Top of Fuel Tank
10. Fuel Filter, Cuno, Type D.S., 1¾ x 1⅝ Cart. .0035 Spacing
11. Fuel Filter, Fram F1104
12. Lub. Oil Filter, Cuno, Type G, .0035 Spacing
13. Lub. Oil Drain
14. Fulton Thermostat Model V-147
15. Radiator Front Screen (Suitable For Mounting Canvas Duct)
16. Oil Cooler — Section of Radiator
17. Hand Crank Assembly
18. Pierce Governor, 1½% Max. Regulation No. GC-438
    United Air Intake Filter No. TO45-11700
20. Instrument Panel with Water Temperature Gauge; Oil Temperature Gauge; Starter Button; Ammeter Alarm Control Switch; Alarm Pilot Light; Alarm Bell.
21. Lub. Oil Filler Cup
22. Vent. — This Line Must Run To Suitable Open Drain Lower Than Fulton Sylphon Safety Control. It Cannot Be Connected To Fuel Suction Line.

Approx. Net Weight of Unit = 3000 lbs. (without batteries and foundation)

10 — ⅝ Dia. Anchor Bolts — 24" Long Overall. ⅝ x 11 U.S. Threads 3" Long (Top End). Lower End of Bolt Bent As Shown in Foundation.
20 — ⅝ U. S. Nuts
20 — ⅝ Washers

Fig. 46 — 15 K.W. A.C. Gen. Set — Installation Plan

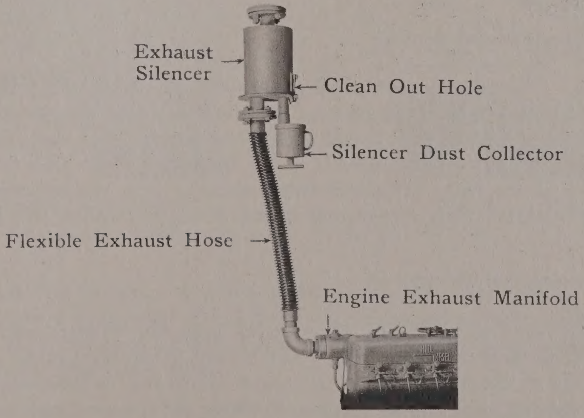

Exhaust Silencer
Clean Out Hole
Silencer Dust Collector
Flexible Exhaust Hose
Engine Exhaust Manifold

Fig. 47 — Exhaust Silencer Connection

position so that the weight of the silencer and tail pipe will not be imposed upon the flexible steel tubing. For the best performance, this flexible steel tubing should have a slight offset. See Fig. 47, Page 51. The outlet tail pipe must be provided with protection against rain entering it.

d. Radiator Cooling Air Connections.— Canvas duct attachment may be made to the front radiator guard to provide a passage for the cooling air from the engine.

e. Electrical Connections.— When the switchboard is in position, the electrical connections can be made from the panel to the exciter, main generator load, and the engine instrument panel (located on the engine). These connections will be "TWELVE" in number at the switchboard. See Figs. 48, 49, 50, 51, and 52; page 53.

FOUR of these connections are for the supply "LINE" leads from the main generator. These leads are stamped "T1," "T2," "T3," and "TO" on the main generator leads. While connecting the main generator leads to the switchboard, be sure that the generator lead marked "TO" is connected to the stud marked "NEUTRAL" on the switchboard connection block. The other three main generator leads marked "T1," "T2," and "T3," are connected to the three studs marked "LINE 1," "LINE 2," and "LINE 3" on the switchboard connection block.

FOUR of the connections are for the "LOAD" leads. When connecting the load leads to the switchboard, be sure that the neutral lead is connected to the stud marked "NEUTRAL" on the switchboard connection block. The other three leads are connected to the switchboard connection block studs marked "LOAD 1," "LOAD 2," and "LOAD 3."

For convenience, solderless lugs are provided for making line and load connections on the switchboard.

TWO of the connections are for the main generator exciter leads. These two connections marked "F1" and "A2" on the switchboard terminal block are connected to the correspondingly marked leads on the main generator exciter.

The TWO remaining connections marked "S" on the switchboard terminal block are connected to the two binding posts on the engine instrument panel.

f. Batteries and Battery Connections.—

(1). Batteries.— The batteries are shipped dry with the plates in a partly-charged condition. Six gallons of electrolyte are required to fill the four 3-cell batteries which make up the 24-volt starting unit. This electrolyte is dilute sulphuric acid and should be poured from the carboys into a glass or porcelain container before attempting to transfer it to the batteries. Flush skin with fresh water if the acid is splashed or spilled on the body. This electrolyte must be pure and suitable for storage battery use and of 1.270 specific gravity. The temperature of the filling electrolyte should not exceed 90° F.

To Prepare the Batteries for Service. —

(a). Unscrew the vent plugs and fill each cell with the prepared electrolyte. This battery is equipped with a non-flood vent plug and cover. The proper filling level is 3/8" above the top of the separators or at the bottom of the filling well of the cover. The valve or lead ring that normally limits filling to the bottom of the well may not function until thoroughly wetted by the first charge. Excess electrolyte above this point should be removed.

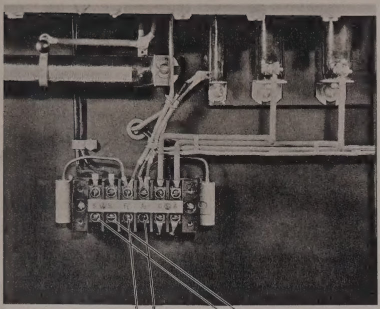


Fig. 49 — Switchboard Terminal Block Connections

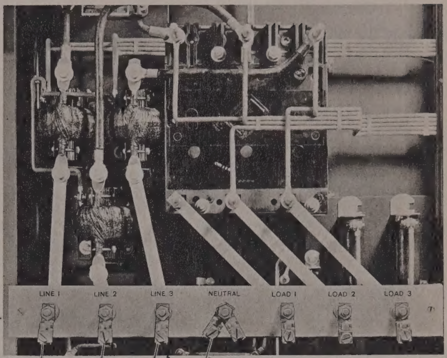


Fig. 48 — Switchboard Connection Block

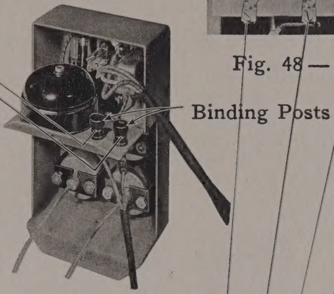


Fig. 52 — Engine Instrument Panel — Rear View

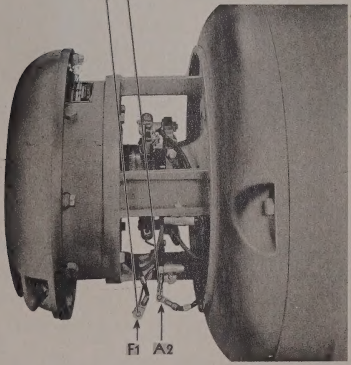


Fig. 50 — Exciter Connections

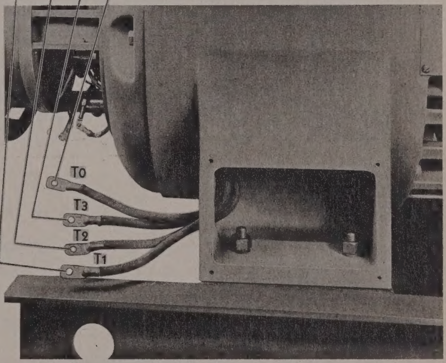


Fig. 51 — Alternator Connections

(b). Allow the batteries to stand at least one hour after filling with electrolyte. If level has fallen, add electrolyte to restore it. Replace the vent plugs in the cells. If any electrolyte was spilled on the battery, it should be removed by means of a cloth slightly dampened with a solution of bicarbonate of soda and water. Then rinse with water.

(c). The batteries may be placed in service temporarily although a freshening charge is desirable. If a freshening charge is to be given follow the instructions given in the "Maintenance" section covering batteries.

(2). Battery Connections.— The batteries should be placed in the battery rack and placed beside the engine as shown in Fig. 53.

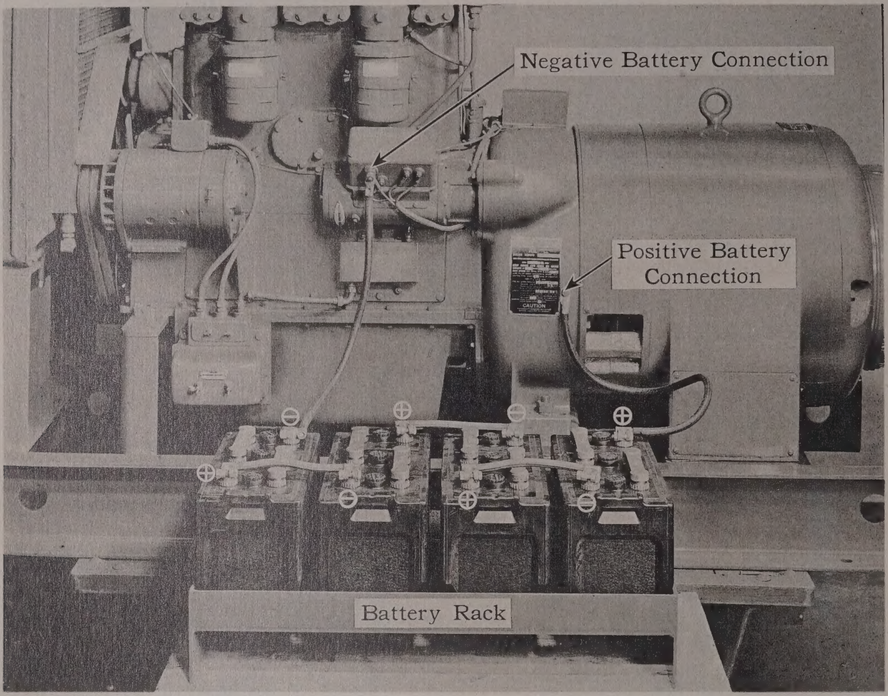


Fig. 53 — Battery Connections

Connect the four 3-cell units in series, that is, positive of one to negative of the other using the three inter-unit connectors supplied. All contact surfaces should be scraped bright and clean before connecting. Apply a film of heavy grease to the connections to prevent corrosion. The free positive and negative end terminals should "NOT" be connected to the unit until the unit is ready to start.

g. Grounding of the Power Unit.—

(1) The steel framework of the power unit should be grounded in at least one spot, preferably in two.

(2) Connect the grounding cable securely to a rod driven into the ground (preferably moist).

(3) The switchboard frame should be grounded similarly, and in addition, should be grounded to the power unit framework.

NOTE

Cable having a cross sectional area of approximately 105,500 circular mils should be suitable for grounding. The length of all grounding cables should be as short as possible.

C. ADJUSTMENT AND OPERATION

1. PREPARING THE ENGINE FOR OPERATION.— It will first be necessary to crank the engine over by hand, using the crank handle provided. When you are certain that all is free, that no parts are rubbing or bearing on one another, you may then proceed with the other operations necessary to prepare the engine for starting.

2. COOLING SYSTEM.— Fill the radiator at the cap provided with approximately 7 gallons of fresh water. When water has risen to the top of the filler hole, replace the cap.

A check should be made at this time to determine that the belts which drive the water pump are properly adjusted. This should be done in accordance with instructions in "Maintenance" section, under cooling system.

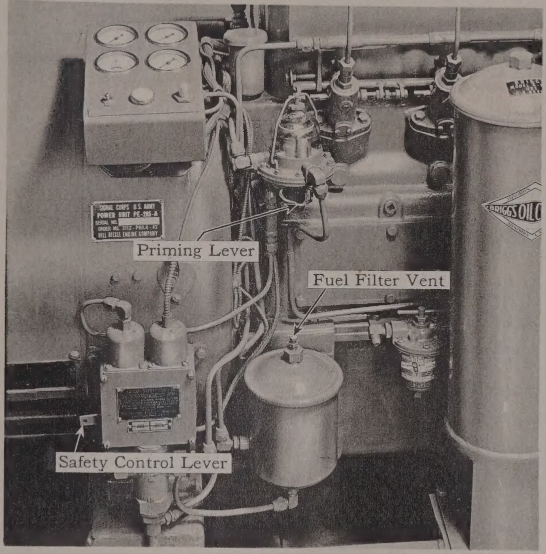


Fig. 54 — Priming the Engine

3. FUEL OIL SYSTEM.—

a. Priming the engine.— When the engine is started for the first time, or after it has been overhauled, the fuel lines drained, or the fuel tank run dry, it will be necessary to prime the engine to remove all the air from the lines. This is accomplished by opening the vent on the top of the cartridge type fuel filter and pumping the priming lever by hand. This vent should be left open until fuel runs out clear with no evidence of air bubbles. Close the fuel filter vent, lift safety control lever and continue pumping the priming lever until the fuel discharges into the fuel tank.

b. Fuel oil specifications.— Fuel oil should be a neutral distillate petroleum oil, free from suspended matter, and not a mixture of light oil and heavy residue. A good clean grade of No. 2, 3, or 4 Diesel or furnace oil can be used.

Chemical properties should be approximately as follows:

Heat value, BTU minimum per lb.	18500
Specific gravity at 60° F.	.887-.845
Gravity A.P.I.	28-36
Flash point maximum	150° F.
Pour point maximum	0° F.
Viscosity SU @ 100° F.	35-50 sec.
Ash maximum	.1%
Asphalt, hard and soft, maximum	.3%
Sulphur maximum	1.0%
Water and sediment	1.0%

Extremely light oils, such as kerosene, will burn satisfactorily, but there is no lubricating value in such light oils and their use will result in damage to parts which depend upon fuel oil for lubrication.

4. LUBRICATING OIL SYSTEM.— The engine crankcase should be filled with about 8 gallons of lubricating oil. When the engine is new it is advisable that a No. 20 straight mineral oil of good quality be used.

No special grade of lubricating oil is used for breaking in the engine. The grade of oil used is almost entirely dependent on the weather conditions.

a. Lubricating Oil Specifications.— The following are the recommendations for lubricating oil which best cover the conditions of engine operation:

Ambient Temperature	Grade of Oil
90° F. and above	S.A.E. No. 30
30° F. to 90° F.	S.A.E. No. 20
30° F. and below	S.A.E. No. 10

5. AIR INTAKE SYSTEM.— Remove the oil cup from each air cleaner by loosening the wing nuts on each side of the air cleaner body. Using lubricating oil of the same grade as used in the engine, fill each air cleaner oil cup to the bead as shown in Fig. 55. Replace the oil cup and fasten it in its original position with the previously mentioned wing nuts.

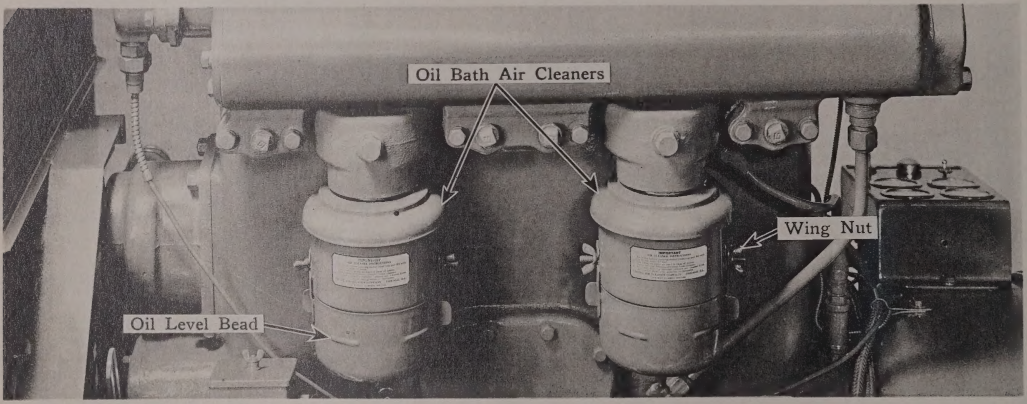


Fig. 55 — Air Intake System

6. EXHAUST SYSTEM.— Before the engine-generator set is started, it is well to check to see that no accumulation of water or dirt has collected in the dust box of the silencer. The silencer dust box may be removed by loosening the bolt at the bottom of the dust box.

7. ELECTRIC STARTING AND BATTERY CHARGING SYSTEM.— Connect the loose positive and negative battery terminals to the engine flywheel housing and starting motor as clearly shown in "Instructions for Installation."

Before attempting to start the engine it is well to recheck the battery cables and jumpers to make certain that they are hooked up correctly. Inspect the engine wiring for loose or corroded connections and for broken leads. Make certain the insulation on the wiring has not become frayed.

8. ALARM AND PROTECTIVE SYSTEM.— To check and see that the alarm and protective system is in working order, make the following tests:

a. With the engine stopped, switch the toggle switch on the engine instrument panel "ON"; the green pilot light on the engine instrument panel should light and the alarm bell should ring. To check further, leave the toggle switch on, the bell ringing and the pilot light lit, then raise the lever on the safety control. This should stop the bell ringing but the pilot light should remain lit as long as the toggle switch on the instrument panel is "ON."

To check the shunt-trip circuit on the switchboard, make the following test:

b. With the toggle switch on the engine instrument panel in the "OFF" position and the engine stopped, close the circuit breaker on the switchboard. Now raise and hold the lever on the safety control in its normal operating position; then switch the toggle switch to the "ON" position and lower the safety control lever slowly until the alarm switch in the safety control makes contact. Immediately, the shunt-trip device in the switchboard circuit breaker, should cause the breaker to trip. The instrument panel alarm bell should ring. Never operate the engine with the toggle switch on the instrument panel in the "OFF" position because it deprives the engine of some of the alarm and protective features built into the unit.

9. SWITCHBOARD.— Before starting the engine it will be necessary to:

a. Turn the exciter field rheostat to a maximum clockwise direction.

b. Put generator circuit breaker in "OFF" position.

c. Put voltage regulator manual control switch in "OFF" position as shown in Fig. 58, Page 60.

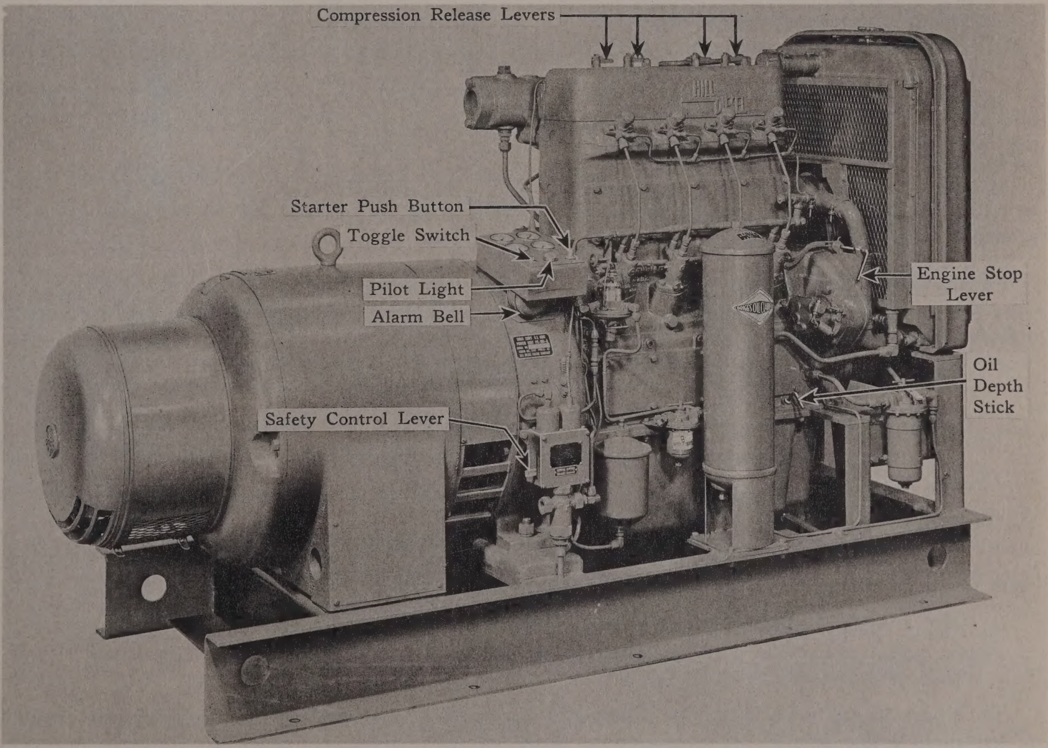


Fig. 56 — Operating the Engine

10. STARTING THE ENGINE.—

a. Don't start the engine until you have checked the following:

(1). The engine turns over freely by hand.

(2). Water is in the cooling system to the top of the radiator.

(3). The engine has been primed and the fuel system is free from air.

(4). Lubricating oil is in the crankcase up to the full mark as shown by the dip stick.

(5). The air cleaners are filled with clean lubricating oil.

(6). The exhaust silencer dust collector has been inspected.

(7). The alarm system has been checked.

(8). All wiring has been thoroughly inspected and checked.

b. Electric Starting.—

(1). Turn the engine stop lever down into its running position.

(2). Using the left hand hold the safety control lever all the way up then press the instrument panel starter button all the way down with the right hand. Hold in this position until the engine increases its speed from its own power. The engine should now pick up to about 1200 revolutions per minute and run smoothly.

(3). When the lubricating oil pressure gauge shows about 25 lbs. release the safety control lever.

(4). It is important that the starter push button should not be held down for more than one minute. A longer period would probably fuse the points on the magnetic switch and damage the starting motor.

If the engine fails to start on the first trial, allow a two-minute interval for the starting motor to cool. DO NOT CHANGE ANY ADJUSTMENTS. Attempt to start the engine again using the procedure outlined above.

(c). Hand Starting.—

(1). Release the compression on all cylinders by pulling the compression release lever on the cylinder head cover into an upright position.

(2). Turn the engine stop lever down into its running position.

(3). Lift the safety control lever and prop in position.

(4). Use the hand crank and spin the engine as fast as possible.

(5). When maximum cranking speed is reached, push the compression release lever on the No. 1 cylinder into a horizontal position.

(6). When the No. 1 cylinder on the engine has "fired" a few times push the remaining compression release levers into a horizontal position and the engine will gather speed and run smoothly.

(7). When the lubricating oil pressure gauge shows about 25 lbs. release the safety control lever.

11. WHEN THE ENGINE STARTS.—

a. Check the oil pressure gauge. Normal oil pressure at operating speed is 25-50 lbs. Oil pressure of less than 25 lbs. calls for an investigation. If no pressure shows, shut down the engine immediately and locate the trouble.

b. Check the ammeter gauge. This meter should show a reading of 8-10 amperes charge. If it should show discharge, check the battery connections.

c. Run the engine at operating speed for a period of about 10 minutes then stop the engine.

(1). Recheck the oil level in the crankcase. DO NOT CHECK THE OIL LEVEL WHILE THE ENGINE IS RUNNING. The oil level at this time might be found low. This is because considerable oil is required to fill the oil filters, the oil cooler and the engine oil passages. Refill to the full mark indicated by the oil depth stick.

(2). Check the water level in the radiator. If the water level is found to be low refill until the water level is brought up to the top of the filler hole.

d. Ordinarily full load should not be applied to the engine until it has run about 15 minutes. IN AN EMERGENCY, FULL LOAD MAY BE APPLIED AFTER THE ENGINE HAS RUN ABOUT 30 SECONDS.

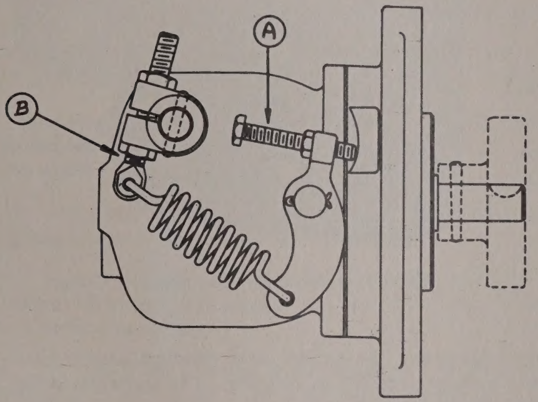


Fig. 57 — Engine Governor Adjustment

12. ENGINE GOVERNOR ADJUSTMENT.—

When the engine leaves the factory the governor is in complete adjustment for both engine speed and governor sensitivity. Normally, no adjustments of the governor will be necessary. If it appears that governor adjustments are necessary, allow the engine to run at least 30 minutes before changing any adjustments. If adjustments must be made, proceed as indicated below.

a. Engine Speed Adjustment.— Adjust the engine speed at screw (A). Turning this screw in (clockwise) increases the tension on the governor spring and increases the engine speed. Turning the screw out (counter-clockwise) decreases the engine speed.

b. Governor Sensitivity Adjustment.— Spring eye screw (B), regulates governor sensitivity. Shortening the effective length of this screw by moving the spring eye toward the rocker shaft, increases governor sensitivity. Increasing the effective length of the screw moving spring eye away from the rocker shaft, broadens regulation.

Should the governor surge under load conditions, lengthen the screw a turn or two at a time until the surge is eliminated.

13. STOPPING THE ENGINE.—

a. First put the circuit breaker on the switchboard in the "OFF" position, and allow the engine to run with no load for a period of about 5 minutes.

b. Turn the engine stop lever in a clockwise direction to the stop position.

c. Check the oil level, and clean engine thoroughly, to make sure it is in proper condition for the next run.

d. If engine room temperature is apt to fall below 32° F. be sure a suitable quantity of anti-freeze solution is in the cooling system to prevent freezing. Run the engine for a few minutes after adding anti-freeze to insure proper mixing.

14. OPERATING THE SWITCHBOARD.— Before placing the switchboard in operation for the first time, be sure that all connections are made properly as given in INSTRUCTIONS FOR INSTALLATION, Page 52.

a. Voltage Control.—

(1). Manual Voltage Control.— Manual control means proper and frequent changing of the exciter field rheostat setting by hand to compensate for voltage changes due to the changes in the load. Since the function of the voltage regulator is to do automatically and quickly what the operator can do more slowly by hand, it is necessary that the operator be familiar with manual control in order that he may obtain the maximum benefits that may be had by the use of an automatic voltage regulator.

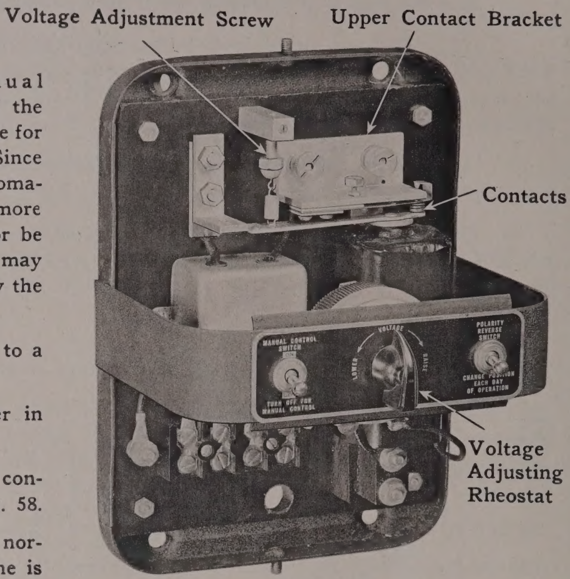


Fig. 58 — Voltage Regulator — Cover Removed

(a). Turn the exciter field rheostat to a maximum clockwise direction.

(b). Put generator circuit breaker in "OFF" position.

(c). Put voltage regulator manual control switch in "OFF" position, as shown in Fig. 58.

(d). Start the engine and operate at normal speed of about 1200 RPM. When the engine is running properly, return to the switchboard.

(e). Turn the voltmeter switch to the number ONE position. Now by observing the A.C. voltmeter on the switchboard, raise the A.C. voltage by turning the exciter field rheostat slowly in a counter-clockwise direction until the proper operating voltage (208 V) is reached. The switchboard is now being operated by what is known as "MANUAL CONTROL."

When the generator is running with a normal A.C. voltage of 208 volts and the circuit breaker is "OFF," it will be noticed that the four synchronizing lights will light dimly if a load is connected to the switchboard. This is a normal condition when the switchboard is operating as a single unit.

As the engine reaches a normal speed of about 1200 RPM, the frequency meter will indicate the number of cycles per second the generator is producing. Raising or lowering the speed of the engine will change the frequency. If for any reason the speed of the engine was below 1160 or above 1240 RPM, the frequency produced would be below 58 or above 62 cycles which is out of the range of the frequency meter. Therefore, it would show no reading. If necessary, the governor should be adjusted to maintain a frequency of 60 cycles at nearly full load.

You are now ready to assume load. This is done by switching the circuit breaker to the "ON" position. The synchronizing lights will go out when the circuit breaker is switched "ON." Now turn the ammeter switch to each of the three positions and the ammeter will register, showing the amount of current in each line being furnished by the generator to the load.

(2). Automatic Voltage Control.— Because the regulator is an electro-mechanical instrument, it can function accurately only when it has been properly put in operation. In order to do this, operators should read and follow carefully the instructions given in the following paragraphs. After the regulator has been put in operation properly, the operator, with some practice, will soon become familiar in the proper switching and rheostat setting which will facilitate operation and will receive all the benefits which may be derived from the use of an automatic voltage regulator.

(a). Turn the exciter field rheostat, to a maximum clockwise direction.

(b). Put generator circuit breaker in "OFF" position.

(c). Put voltage regulator manual control switch in "OFF" position as shown in Fig. 58, Page 60.

(d). Start the engine and operate at normal speed about 1200 RPM. When the engine is running properly, return to the switchboard.

(e). Set the voltage adjusting rheostat on voltage regulator to the mid-position. Fig. 58, Page 60.

(f). Now to obtain the proper operating position of the exciter field rheostat adjust A.C. voltage slowly (By means of the exciter field rheostat) until it is about 25% of normal generator voltage (about 50 or 55 volts). This is known as the "OPERATING POINT." Do not change the position of this rheostat from the operating point unless changing to manual control.

(g). Turn the voltage regulator manual control switch to the "ON" position. The voltage regulator will now automatically bring the A.C. voltage up to approximately normal voltage (208 volts).

(h). Adjust to the proper operating voltage (208 volts) by means of the voltage adjusting rheostat on the voltage regulator.

(i). You are now ready to assume the load with automatic voltage regulation. This is done by switching the circuit breaker to the "ON" position. The voltage should remain at the previous selected point of about 208 volts.

The regulator should vibrate regularly except at moments when load has been added or removed, at which time the regulator vibration will hesitate slightly or just long enough for the voltage to return to normal.

(3). To Change from Automatic to Manual Control.— To change from automatic voltage regulation to manual control without interrupting the service, turn the exciter field rheostat in a counter-clockwise direction until the voltage has increased to about 10% above normal. (225 to 230 volts.) The voltage regulator manual control switch can then be turned off and the generator will be on "MANUAL CONTROL."

(4). To Change from Manual to Automatic Control.— To place the regulator in use without interrupting the service, lower the voltage by turning the exciter field rheostat clockwise until the voltage is about 10% below normal (185-190 volts). Turn the voltage regulator manual control switch "ON," then turn the exciter field rheostat immediately to the normal automatic regulation "OPERATING POINT."

(5). Voltage Regulator Adjustments.— There are four adjustments that may be made on the voltage regulator. These will be better understood by following Fig. 58, Page 60.

The first one is the voltage adjusting rheostat which is mounted on the front of the regulator. This rheostat is used to raise or lower the voltage when the voltage regulator is in operation.

The second adjustment is the voltage adjustment screw. With the regulator in operation, set the voltage adjusting rheostat in mid-position. Loosen the set screw in the end of the supporting post and turn the adjustment screw for voltage adjustment. The voltage is increased with increased spring tension. Tighten the set screw when voltage is correct. The rheostat on the cover will now adjust the voltage approximately 12 volts either side of the selected value.

The third adjustment is the small vertical screw on the upper contact bracket. This screw adjusts the initial tension of the contact leaf-spring, and subsequently, the "follow thru" of the contact engagement. A heavy leaf-spring tension causes "bouncing" of the lower contact, while a slight tension causes "hunting." The proper tension is that which is barely enough to prevent hunting and which barely has a distinct 120-cycle tone of vibration.

The fourth adjustment is the location of the upper contact bracket relative to the vibrating contact and the fact of the magnet core. The two mounting holes of this bracket are made large so that positioning is possible. The bracket should be located (especially when replacing contacts) in such a manner that the upper and lower contacts butt together evenly, and that the distance between contacts is between .025″ and .040″. The distance between contacts is measured by disconnecting the voltage adjusting spring so as to allow the vibrator to rest lightly on the bumper pad at the top of the core. The stop on the leaf-spring contact should be resting against the horizontal upper surface of the contact bracket. A general rule is to have a gap just long enough to prevent the vibrator from falling into synchronous vibration when maximum load on the generator is suddenly dropped.

b. Circuit Breaker Adjustment.— If the breaker should be tripped by the Thermal-Magnetic trip unit or the shunt trip device, the breaker handle will be in a tripped position. The breaker will have to be "RESET" before it can be operated again. To Reset:—Push breaker handle to the extreme "OFF" position, and the trip mechanism will automatically be restored to the operating position.

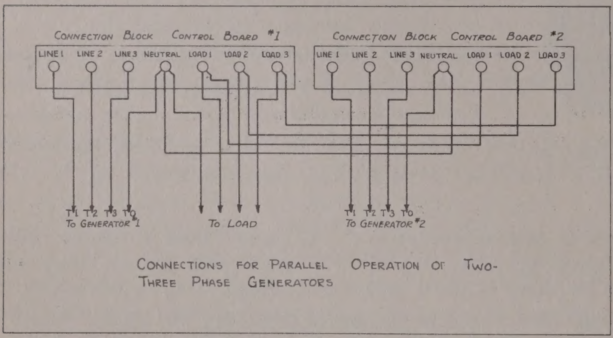


Fig. 59 — Switchboard Connections

(1). Explanation of synchronizing for parallel operation.— Synchronizing is the act of connecting two or more units of similar design in parallel so as to deliver the output of these units to the same load. Connecting the units in parallel increases the amount of load that can be connected. When it is desired to synchronize two generators together, it will be necessary to connect the load connections in parallel. That is, to run cables for the load and neutral connections of the first unit. These cables should be connected so that the studs marked "LOAD 1," "LOAD 2," "LOAD 3," and "NEUTRAL" on one switchboard are connected to correspondingly marked studs on the other switchboard. (Refer to Fig. 59.) A self-contained synchronizing circuit is employed on the switchboard. The four synchronizing lights are permanently connected and require no connecting or switching. These lights are connected to synchronize on what is known as "THE DARK LAMP METHOD." That is, when the lights are out, the generators are in step.

(2). Phase Rotation.— In the case of three-phase generators which are to be operated in parallel, it is not only necessary that the frequency and voltage be the same, but that the "phase rotation" be the same. A simple check can be made using the following procedure:

(a). With the circuit breakers on both units in "OFF" position, start both engines and bring to normal speed.

(b). Return to the switchboards and put the voltage regulators on both units into operation. Then adjust the voltage on both units by means of the voltage adjusting rheostat ON THE REGULATORS to the same voltage, or as close as possible.

(c). Switch the circuit breaker on the first unit to the "ON" position. It will be noted the lights on the first unit are now out.

(d). Now, observe the synchronizing lights on the second unit. They should pulsate up and down in brilliance together. That is, all out or all on at once. If the lights pulsate alternately, that is, the top lights are out when the bottom lights are on, or vice-versa, it indicates that a wrong connection has been made between generators and switchboards, or between switchboards. Shut down both engines and make a thorough check of all connections. If all connections appear to be correct by number, it is possible that a mistake was made in generator lead markers.

To correct: Interchange any two line wires of one generator at the switchboard. Now start both units as stated in steps "(a)," "(b)," and "(c)," and check synchronizing lights. They should pulsate together, and it is now possible to synchronize the generators together, using the following procedure:

(3). Procedure of synchronizing.—

(a). With the circuit breakers on both units in the "OFF" position, start both engines and bring to normal speed.

(b). Return to the switchboards and put the voltage regulators on both units into operation. Then adjust the voltage on both units, by means of the voltage adjusting rheostat on the regulators to the same voltage or as close as possible.

(c). Switch the circuit breaker on the first unit to the "ON" position. It will be noted that the lights on the first unit are now out.

(d). Now, observe the synchronizing lights on the second unit. If they pulsate up and down in brilliance, it indicates that one engine is running too fast or too slow.

(e). Check the frequency meter indication to determine the slow or fast engine. Adjust its governor so the synchronizing lights pulsate very slowly or not at all.

(f). When the lights are out, switch the circuit breaker on the second unit to the "ON" position.

CAUTION —

CAUTION WHEN SYNCHRONIZING.— Never switch the circuit breaker on the second unit to the "ON" position when the lights are on, or if the lights pulsate alternately. It may cause damage to the generating equipment.

(g). The units are now operating in parallel. A certain amount of adjusting will have to be done to cause the units to share the load equally. This adjustment is as follows:

(4). Dividing the Load Equally Between Generators.—

In order to have the units share the load equally, the A.C. ammeters on both switchboards should have the same reading. Unequal readings of A.C. ammeters are caused by one or both of the following causes:

First: By unequal setting of the engine governors.

Second: By cross currents between generators caused by unequal generator excitation.

Since the voltage regulator circuit on the switchboard is equipped with a cross-current compensating transformer and resistor to prevent cross currents, it may be assumed that the engine governor settings are not equal. The adjustment on the cross current resistor which is connected to the cross current transformer, is set for best results by the switchboard manufacturer, and should not be changed. Although changing the adjustment will not damage the equipment, it will make parallel operation unstable.

To determine which engine governor to adjust and which way to adjust it, use the following steps:

(Note: Better results can be obtained while making adjustments if the units are operated with a load.)

(a). With both units running in parallel, check the A.C. ammeter and frequency meter readings.

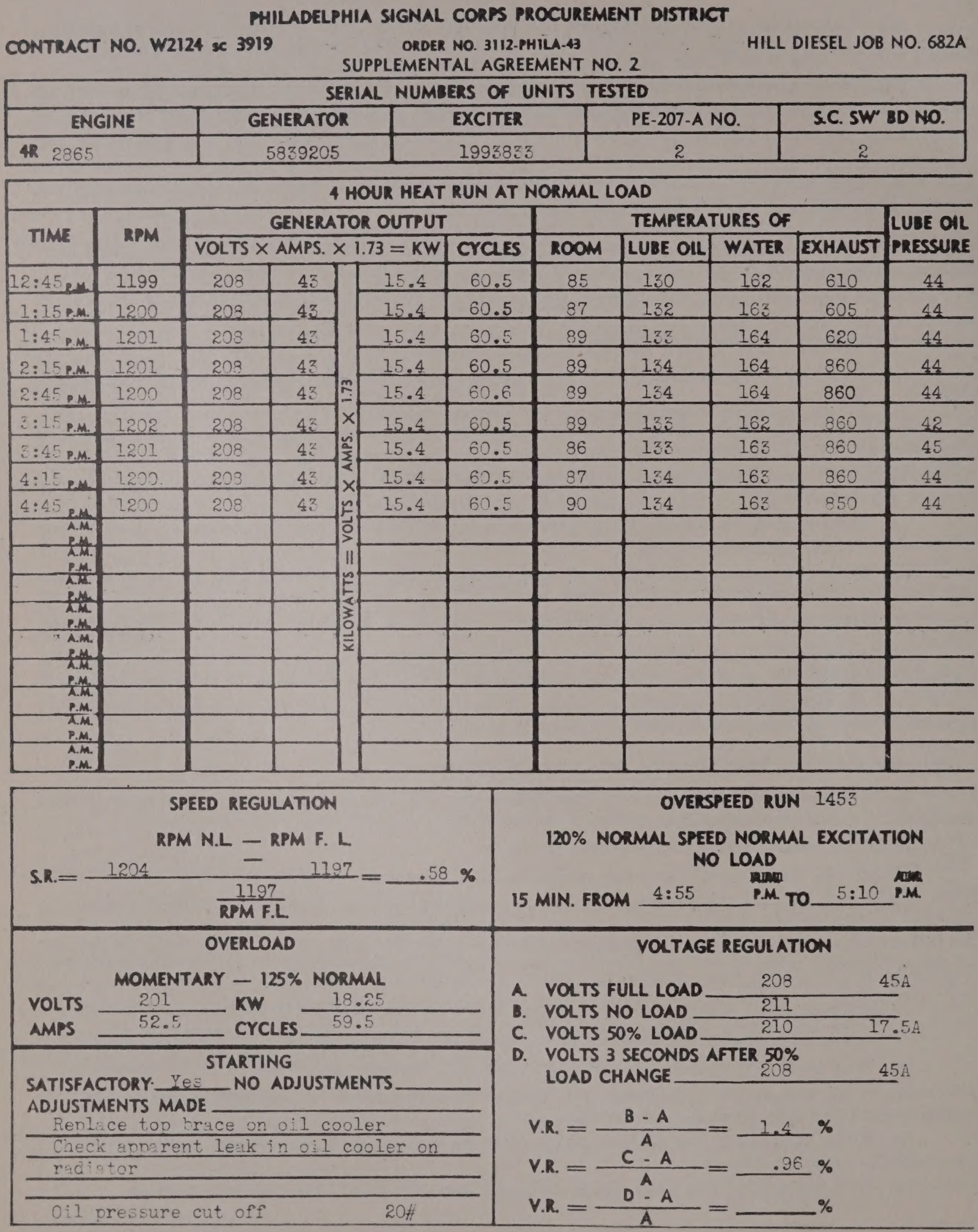
(b). If the frequency is high, reduce the speed of the engine whose A.C. ammeter reading is high until the A.C. ammeters on both switchboards read the same.

(c). If the frequency is low, increase the speed of the engine whose A.C. ammeter reading is low until the A.C. ammeters on both read the same.

(d). In most cases, a very small governor change will be required to correct the unbalance.

15. TYPICAL SET OF TEST DATA.—

Fig. 60, Page 64, shows typical data taken during the inspection and acceptance of the equipment.



PHILADELPHIA SIGNAL CORPS PROCUREMENT DISTRICT

CONTRACT NO. W2124 sc 3919 **ORDER NO. 3112-PHILA-43** **HILL DIESEL JOB NO. 682A**

SUPPLEMENTAL AGREEMENT NO. 2

SERIAL NUMBERS OF UNITS TESTED				
ENGINE	**GENERATOR**	**EXCITER**	**PE-207-A NO.**	**S.C. SW' BD NO.**
4R 2865	5839205	1993833	2	2

4 HOUR HEAT RUN AT NORMAL LOAD

TIME	RPM	GENERATOR OUTPUT					TEMPERATURES OF				LUBE OIL PRESSURE
		VOLTS × AMPS. × 1.73 = KW				CYCLES	ROOM	LUBE OIL	WATER	EXHAUST	
12:45 P.M.	1199	208	43	KILOWATTS = VOLTS × AMPS. × 1.73	15.4	60.5	85	130	162	610	44
1:15 P.M.	1200	208	43		15.4	60.5	87	132	163	605	44
1:45 P.M.	1201	208	43		15.4	60.5	89	133	164	620	44
2:15 P.M.	1201	208	43		15.4	60.5	89	134	164	860	44
2:45 P.M.	1200	208	43		15.4	60.6	89	134	164	860	44
3:15 P.M.	1202	208	43		15.4	60.5	89	133	162	860	42
3:45 P.M.	1201	208	43		15.4	60.5	86	133	163	860	45
4:15 P.M.	1200.	208	43		15.4	60.5	87	134	163	860	44
4:45 P.M.	1200	208	43		15.4	60.5	90	134	163	850	44
A.M. P.M.											
A.M. P.M.											
A.M. P.M.											
A.M. P.M.											
A.M. P.M.											
A.M. P.M.											
A.M. P.M.											
A.M. P.M.											
A.M. P.M.											

SPEED REGULATION

RPM N.L. — RPM F. L.

S.R. = 1204 — 1197 / 1197 = .58 %

RPM F.L.

OVERSPEED RUN 1453

120% NORMAL SPEED NORMAL EXCITATION

NO LOAD

15 MIN. FROM 4:55 ~~A.M.~~ P.M. TO 5:10 ~~A.M.~~ P.M.

OVERLOAD

MOMENTARY — 125% NORMAL

VOLTS 201 KW 18.25

AMPS 52.5 CYCLES 59.5

VOLTAGE REGULATION

A. VOLTS FULL LOAD 208 45A

B. VOLTS NO LOAD 211

C. VOLTS 50% LOAD 210 17.5A

D. VOLTS 3 SECONDS AFTER 50% LOAD CHANGE 208 45A

$$V.R. = \frac{B - A}{A} = 1.4\ \%$$

$$V.R. = \frac{C - A}{A} = .96\ \%$$

$$V.R. = \frac{D - A}{A} = \_\_\_\ \%$$

STARTING

SATISFACTORY Yes NO ADJUSTMENTS

ADJUSTMENTS MADE

Replace top brace on oil cooler

Check apparent leak in oil cooler on radiator

Oil pressure cut off 20#

Fig. 60 — Test Record

D. MAINTENANCE AND REPAIR

The following maintenance and repair recommendations are made so that equipment may be kept in proper operating order at all times.

By keeping the unit clean inside and out, a high percentage of the causes of poor engine performance can be eliminated.

If unusual noise or vibration develops in the engine at any time, the engine must be shut down, the cause located and corrected.

CAUTION: If any repairs are to be made that involve removing any part on the unit, the battery cables must be disconnected from the engine.

CAUTION: When tightening or removing tubing fittings it is good practice to hold the tubing union with one wrench and turn the nut with the second wrench.

1. MAINTENANCE SCHEDULES.— The following schedules must be adhered to in order to obtain satisfactory operation of equipment.

DAILY

a. Check lubricating oil level in crankcase.
b. Check water level in cooling system.
c. Test the alarm system.
d. Reverse polarity on voltage regulator.
e. Turn cleaning handle of metal edge type fuel and lubricating oil filters at least twice a day.
f. Clean air cleaner cups and refill with new lubricating oil.
g. Drain the cooling system, after stopping engine, in freezing weather.
h. Wipe down generator set and switchboard.
i. Check water level in batteries.

50 HOURS

a. Drain metal edge filters.
b. Clean sediment bowl and screen of fuel transfer pump.
c. Check battery gravity.

100 HOURS

a. Minor engine tune-up.
b. General inspection of starting motor.
c. General inspection of charging generator.
d. Lubricate starting motor.

200 HOURS

a. Drain and flush crankcase — change oil.
b. Change all cartridge type filters.
c. Clean dust box of exhaust silencer.

300 HOURS

a. Flush out air cleaners.
b. Tighten all electrical connections.
c. Tighten V-belts.
d. Clean battery terminals.

1000 HOURS

- **a.** Clean and flush radiator and oil cooler.
- **b.** Drain and clean fuel supply tank.
- **c.** Clean and test fuel injection nozzles.
- **d.** Clean lubricating oil pump screen and relief valve assembly.
- **e.** Clean interior of exhaust silencer.
- **f.** Starting motor tune-up.
- **g.** Charging generator tune-up.
- **h.** Check meters.

2000 HOURS

- **a.** Minor engine overhaul.
- **b.** Inspect bearings.
- **c.** Inspect valves and seats — remove carbon.
- **d.** Inspect valve and fuel pump tappets.
- **e.** Starting motor overhaul.
- **f.** Charging generator overhaul.

4000 HOURS

- **a.** Major engine overhaul. Tear the engine completely down and clean all parts. Replace worn parts and all gaskets.

2. ENGINE.—

a. Table of Clearances.—

Piston in Cylinder Sleeve	.006 to .008
Ring Gap, 3 Compression Rings ⅛"	.015
Ring Gap, 2 Oil Control Rings ¼"	.015
Piston Pin in Piston	.0000 to .0003 Tight @ 70° F
Piston Pin in Upper Rod Bearing	.0015 to .003
Connecting Rod Lower Bearing	.0025 to .0040
Main Bearings	.0025 to .0040
Valve Stem	.0015 to .0035
Valve Tappet Adjustment, Cold	.015
Timing Gear Backlash	.003 to .006
Camshaft Bearing	.002 to .003
Camshaft End Clearance	.005 to .010
Crankshaft End Clearance	.005 to .015

b. Engine Timing in Crankshaft Degrees.—

Injection Begins	20°	Before Top Dead Center
Injection Ends	6°	Before Top Dead Center
Injection Period	14°	At Full Load
Exhaust Valves Open	40°	Before Bottom Dead Center
Exhaust Valves Close	10°	After Top Dead Center
Exhaust Period	230°	
Intake Valve Open	5°	Before Top Dead Center
Intake Valve Close	45°	After Bottom Dead Center
Intake Period	230°	

c. Cooling System.— Lift the radiator cap once a day and check to see that the cooling system is full; add soft clean water as level drops to restore same to top. Excess water will drain thru the overflow pipe.

In cold weather if anti-freeze is not used in the cooling system, the engine must be drained at the pipe plug in the side of the cylinder block and at the drain pipe located under the radiator.

In cold weather anti-freeze should be used in the proportion given below.

Amount of Anti-Freeze	Freezing Point
3 qts.	27° F
6 "	19° F
9 "	10° F
12 "	— 2° F
15 "	—18° F
18 "	—38° F

The anti-freeze solution should be drained from the cooling system when all danger of freezing is past. Flush the cooling system thoroughly until it is clean and refill with soft clean water.

(1). Radiator.—

(a). Cleaning.— It is recommended that the entire cooling system be thoroughly cleaned every 1000 hrs. of operation. This may be accomplished as follows: Add to the system one pound of washing soda or commercial Radiator Cleaning Compound as purchased from a grocery store or auto supply store for every gallon of water circulated. This solution may be allowed to remain in the system for several days, or as long as one week, while the installation operates. During this time the washing soda will loosen up scale and other sediment deposited on the walls of the radiator and engine. At the end of this period the entire system should be drained by removing the lower hose connection. This will enable all sediment in the system to drain out. DO NOT DRAIN THRU PET COCK AS THE OPENING IS TOO SMALL. The system should then be thoroughly flushed out and refilled with clean water. If unable to properly clean out radiator with the above method, it should be boiled out in a chemical cleaning solution by a radiator repair shop with suitable equipment.

(b). Removing the Radiator from the Engine.— Drain the entire cooling system by removing the pipe cap from the drain pipe under the left side of the radiator and also removing the ½″ pipe plug in the left side of the cylinder block.

Loosen the top radiator hose clamp next to the radiator. Remove the safety control thermo-bulb from the thermostat housing. Remove the two cap screws that hold the thermostat housing to the water manifold. Turn the thermostat housing and hose assembly to one side and lift the assembly off. Be careful not to damage the thermostat inside the housing.

Remove the inner radiator fan guard by removing the five round head screws that hold it to the radiator. Lift the fan guard off by pulling its top away from the radiator and lifting upward at the same time. See Fig. 61, Page 68.

Remove the lower radiator hose assembly by loosening the hose clamp next to the water pump and the hose clamp next to the bottom of the radiator.

Remove the ½″ steel tubing oil line between the metal edge type filter and the left side of the oil cooling section of the radiator. Remove the ½″ steel tubing oil line between the right side of the oil cooling section and the cylinder block. In taking these lines off do not remove any pipe fittings, just loosen the tubing nuts and pick the tubes off.

Remove the radiator drain tube with a pipe wrench. If this is not done it may cause a leak around the soldered flange on the radiator. Remove the two ½″ nuts from the studs that hold the radiator to the subbase. Pull the radiator forward to clear the fan and lift it off. Care should be taken not to injure the radiator, fan or piping in any way. Fig. 62.

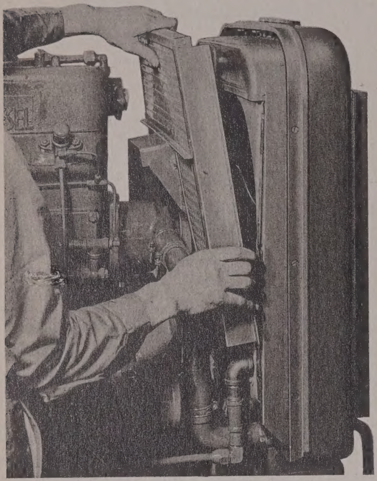


Fig. 61 — Removing Inner Radiator Fan Guard

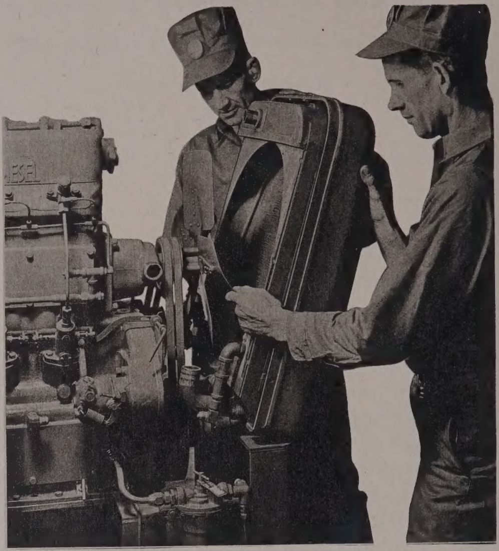


Fig. 62 — Removing Radiator from Engine

(c). Replacing the Radiator.— The radiator should be replaced by reversing the sequence of operations for removal. It is extremely important that the spacer pads between the radiator and subbase are replaced. If these pads are left out the fan may strike the top of the radiator and damage the upper radiator tank.

(2). Fresh Water Pump.— If the water pump leaks, the seal is probably worn or damaged. It will be necessry to remove the water pump to inspect the parts or make any repairs. Before the water pump can be removed, it will first be necessary to remove the radiator.

(a). To Remove Pump from Engine.—

1. Remove the four Allen head cap screws which hold the radiator cooling fan to the water pump drive sheave and lift the fan off.

2. Loosen the V-belt tightener on the charging generator, lift the belts off from the water pump sheave.

3. Remove the four 7/16″ nuts that hold the water pump to the cylinder block and lift the water pump off.

(b). To Disassemble Pump.—

1. Remove the water pump drive sheave with a puller as shown in Fig. 63. Care should be taken in this operation as the sheave is made of cast iron and can be broken by careless handling.

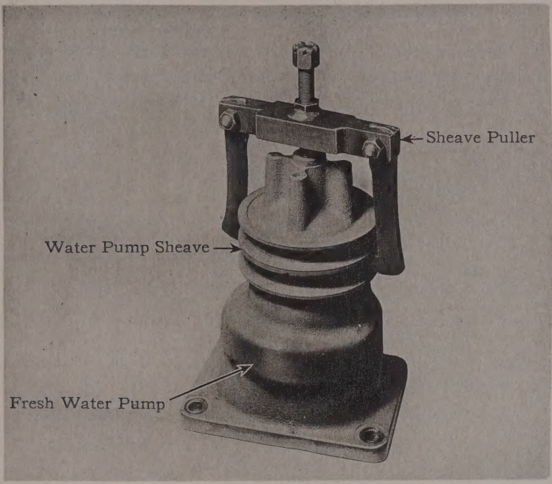


Fig. 63 — Pulling Water Pump Sheave

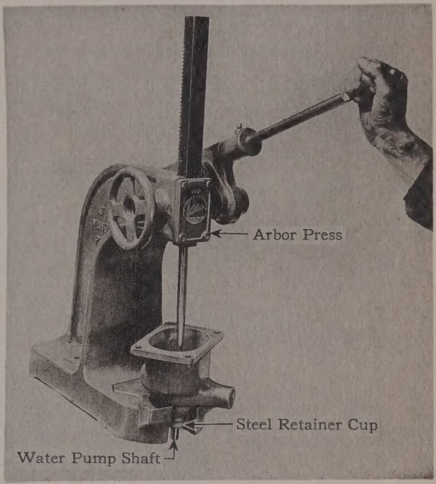


Fig. 64 — Pressing Out Water Pump Shaft

2. Place the water pump in an arbor press as shown in Fig. 64, and press out the impeller shaft. When the shaft is pushed out of the impeller and the water pump housing, the entire pump unit comes apart.

(c). Inspection of parts.— Examine the surface of the pump on which the impeller seal assembly runs. If this surface is not smooth it should be ground and polished. This water pump impeller seal assembly consists of a rubber seal at one end, a fiber seal at the other end and a connecting spring. Usually the rubber seal and spring can be used again, however, if they are damaged they should be replaced. The fiber seal should be checked carefully and should be replaced if any scratches or signs of wear appear on its bearing surface.

The pump bearings and shaft are a solid unit and cannot be disassembled. These bearings should be checked and if they appear to be loose on the shaft they should be replaced. These bearings are a sealed unit and require no lubrication.

(d). To Assemble Pump.—

1. Press the water pump shaft and bearing assembly into the water pump housing.

2. With the seal assembly in place, press the impeller on the shaft until it strikes the pump housing.

3. Using an arbor press as shown in Fig. 64, press the water pump shaft out 1/64″.

4. Turn the water pump over and with the arbor press spindle on the end of the water pump shaft, press the shaft down tight. This allows 1/64″ clearance between the impeller and the inside of the water pump housing.

5. Press the steel retainer cup over the end of the water pump housing by using a 1″ pipe nipple approximately 3″ long.

6. Press the drive sheave onto the end of the water pump shaft until the sheave is flush with the end of the shaft.

(e). V-Belt Adjustment.— After the water pump has been assembled to the cylinder block the V-belts replaced on the sheaves, these V-belts should be adjusted as follows:

Swing the charging generator out until there is about 1″ belt movement when slight pressure is applied at a point midway between the crankshaft sheave and the water pump sheave. See Fig. 65. Tighten the belt tightener in this position. Do not adjust the belt tension too high as this will cause excessive belt and bearing wear.

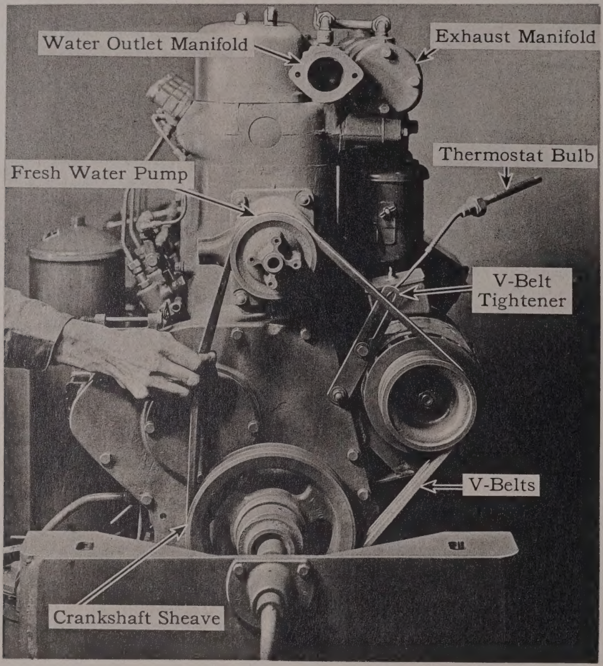


Fig. 65 — V-Belt Adjustment

(3). Thermostat.— The thermostat may require occasional cleaning and could possibly require replacement. These units are gas filled and sealed and it is possible for the bellows to become punctured or broken. If the thermostat should become stuck or broken it will remain open and the engine will run cold. When this happens the thermostat should be replaced as follows:

(a). Drain the engine cooling system.

(b). Loosen the top radiator hose clamp next to the radiator.

(c). Remove the safety control thermobulb from the thermostat housing.

(d). Remove the two cap screws that hold the thermostat housing to the water manifold. Turn the thermostat housing and hose assembly to one side and lift the assembly off.

(e). The thermostat may now be removed from the water manifold.

When replacing the thermostat and thermostat housing it is good practice to use a new gasket and to make certain the thermostat is seated properly in place. This thermostat could be easily damaged by mishandling.

(4). Water Outlet Manifold.— The water outlet manifold should not require any service except cleaning occasionally or replacement if broken or damaged.

(a). Replacement.—

1. Remove the temperature gauge thermobulb from the center of the water outlet manifold. To do this, loosen the small nut on the tube, and pull the tube out of the lower fitting.

2. Remove the thermostat housing and thermostat as described above.

3. Remove the ½″ U-shaped copper tube which connects the exhaust manifold to the water manifold.

4. Remove the six ⅜″ cap screws which hold the manifold in place.

5. The water manifold can now be lifted off the engine.

When the water outlet manifold is reinstalled it is important that all new gaskets are used and that the hold-down capscrews are pulled down tight.

d. Fuel Oil System.— Check all fuel lines and connections daily for leaks.

If any fuel connections are removed from the engine cover the ends of the disconnected lines to prevent dirt from entering.

(1). Fuel Tank.— Fill the fuel tank with a funnel strainer using at least a 150 mesh wire screen which will not allow water to pass thru when it is wet with fuel oil. Extreme care also should be taken to prevent dirt and lint from entering the fuel tank. A small amount of dirt or water could ruin a fuel injection pump or nozzle.

The fuel tank should be drained and flushed of all sludge and water at least each 1000 hrs. of operation.

(2). Metal Edge Type Fuel Filter.— This filter is cleaned by giving the handle one complete turn. This must be done often enough to prevent the cartridge from becoming plugged to such an extent that the handle cannot be readily turned. The time interval between turnings will vary with each job depending on the amount of operation and the amount of dirt in the fuel oil. The handle should be turned at least twice a day unless experience shows longer time intervals are allowable between turnings before the cartridge begins to turn hard. There is no danger of turning the handle too often.

If thru occasional neglect the handle turns hard it should be turned back and forth BY HAND until the cleaners free themselves and the handle can be turned a complete revolution. A WRENCH OR OTHER TOOL SHOULD NEVER BE USED IN AN ENDEAVOR TO TURN A FILTER THAT HAS BECOME CLOGGED. In such circumstances the filter cartridge should be removed and washed in a solvent until it turns freely. DO NOT ATTEMPT TO TAKE THE CARTRIDGE APART.

Remove the drain plug in the bottom of the filter weekly or every 50 hours of operation and drain out all dirt and sludge.

(3). Fuel Transfer Pump.—

(a). Cleaning.— The sediment bowl and screen should be removed and cleaned once each week or approximately every 50 hours of operation.

The sediment bowl and screen may be removed by loosening the thumb nut and moving the wire bail to one side. The bowl and screen may be lifted off and washed in fuel. The bowl may be wiped with a clean cloth. If compressed air is available it may be used to blow the screen out, but care should be used when blowing with air. A direct blast of high pressure air may damage the screen.

When the bowl is replaced, make certain it sets square on the gasket, otherwise it may be broken.

(b). Replacement.— If the fuel pump is faulty it may be replaced as follows:

1. Using one wrench to hold the tubing fittings, with a second wrench loosen the tubing nuts on the suction and discharge lines. Remove the two 5/16″ cap screws holding the pump to the cylinder block. The pump may now be lifted off.

When replacing the pump care should be taken when screwing the fittings into the pump body, as it is a die casting and easily broken.

(4). Cartridge Type Fuel Filter.— The interval between cartridge changes will be governed by the condition of the fuel oil and operating condition of the engine. Experience will indicate the necessity for a new cartridge. Replace the cartridge as often as it shows that dirt is accumulating, as this is your protection against injection system wear and failure. We recommend that the period between cartridge changes be not longer than 200 hours of operation. To change the cartridge proceed as follows:

(a). Remove the drain plug from the bottom of the filter. This is done in order to remove the entrapped dirt from the sump.

(b). Disengage the cover capscrew and remove the old cartridge along with the cork gaskets which seal the center tube at the top and the bottom of the cartridge.

(c). Wipe the inside of the filter body clean and replace the drain plug.

(d). Install new cartridge with a cork gasket around the center tube at both ends of the cartridge.

(e). Replace the vellumoid gasket in the cover recess with the new one provided with the new cartridge.

(f). Replace the filter cover and tighten it securely.

(g). Open the bleed valve in the cover capscrew and pump the fuel transfer pump priming lever by hand until the fuel discharges from the filter vent with no evidence of air bubbles. This procedure will rid the filter of trapped air and the engine should start smoothly.

(5). Fuel Injection Pumps.—

(a). Timing Fuel Injection Pumps.— When the engines leave the factory, the injection pumps are timed precisely and marked to show the number and thickness of copper shims that have been placed under each pump to bring them into time. DO NOT TAMPER WITH THE INJECTION PUMPS UNLESS ALL OTHER POSSIBILITIES OF TROUBLE HAVE BEEN EXHAUSTED.

The fuel injection pump tappet cams, the air inlet valve tappet cams, the exhaust valve tappet cams and the fuel transfer pump lever eccentric are machined on the same camshaft, and cannot be separately adjusted. The camshaft gear teeth mesh directly with crankshaft gear teeth, and both gears are marked for correct timing.

Fuel injection starts 20° before the crankshaft pin has reached top dead center on the compression stroke, and the fuel injection pump plunger has a lift of .100 inches at this point. Assuming that the crankshaft and camshaft gears are correctly meshed, final timing of the fuel injection pumps is made as follows:

1. Disconnect the fuel injection tubing nut at the top of the No. 1 fuel injection pump. Unscrew the delivery valve holder with a socket, flat open end or suitable box wrench. Lift out the delivery valve spring and delivery valve leaving the valve seat in place. Replace the delivery valve holder and pull down fairly tight.

2. Insert a 3/32 inch rod, approximately 3 inches long with a 45° taper at its lower end, into the hole in the center of the pump plunger. Turn the engine over, by engaging the ring gear on the flywheel with a screw driver thru the timing opening in the flywheel housing, until the fuel pump plunger has reached its lowest position.

3. Place a dial indicator on top of the 3/32 inch rod and set at zero. See Fig. 66.

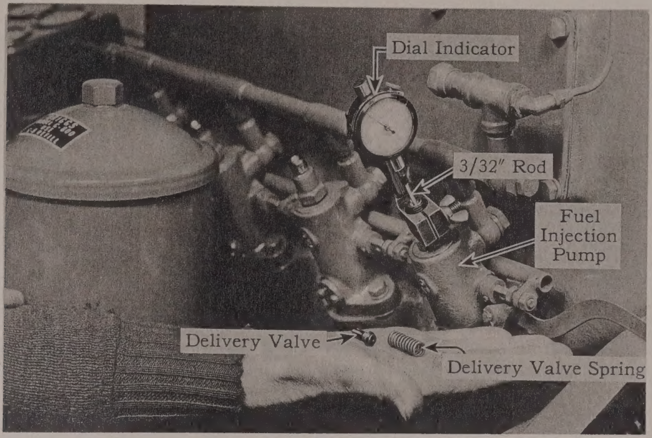


Fig. 66 — Timing Fuel Injection Pumps

4. Turn the engine in the direction in which it rotates until mark on flywheel marked i.s. (injection starts) is directly under the timing pointer, at the same time watching the dial indicator. The indicator should show .100 inches lift at this point. If not proceed as follows:

5. Remove the camshaft timing cover plate at the front end of the engine. Loosen the four locking screws in the camshaft gear. Turn the camshaft ahead or back as the case may be until the indicator reads .100 inches from the zero setting. Tighten the lock screws and recheck as in 2-3-4. Replace the lock wire and cover plate.

6. Turn engine backward until pump plunger is at its lowest point and reset the indicator to zero.

7. Open the throttle and pump the fuel transfer pump lever by hand until fuel flows thru the fuel injection pump past the indicator rod.

8. Continue to pump the pump lever and at the same time turn the engine in the direction it rotates until the fuel just stops flowing thru the fuel injection pump. Note the indicator reading. It should be .100 inches. If not proceed as follows:

9. If for example, the indicator reading should be .105 inches, it would be necessary to remove a .005 shim from under the fuel injection pump. Re-check as in 6-7-8.

10. Replace the fuel pump delivery valve, spring and injection tubing.

11. After the No. 1 fuel injection pump has been timed in the above manner, all the other pumps will be in time, provided each pump has the same total thickness of shims under it as was placed under No. 1.

(b). Maintenance of Fuel Injection Pumps.— Precision workmanship and the best of materials have been used in the manufacture of the fuel injection pump, to assure proper and trouble-free operation over long periods. To avoid costly shutdowns and repairs, it is necessary to observe certain precautions in the care, maintenance and handling of these injection pumps. The most important item is the use of clean fuel oil.

Fuel injection pumps are essentially mechanical devices and as such are subject to occasional breakdowns, often due to external causes. This then necessitates their disassembly and close examination of all component parts to determine the cause of the difficulty.

Whenever fuel injection equipment is removed from the engine and disassembled, it is of the utmost importance that the following essential points of cleanliness be strictly observed.

Before removing the injection pump from the engine and before breaking any of the supply or discharge tubing connections, wash the entire assembly free of dirt and dust with fuel oil or gasoline.

After supply and discharge tubes have been disconnected, close up their open ends with corks, clean cloth or paper caps.

Prior to disassembly of the injection pumps, again wash their exterior with clean fuel oil or gasoline to remove the last traces of grit and dirt.

Place the injection pump on a clean work bench, the top of which should, preferably, be covered with clean paper. Arrange for a container filled with clean fuel oil or gasoline, in which the component parts of the injection pump can be washed thoroughly.

1. To Disassemble Fuel Injection Pump.— The exploded illustration Fig. 67, Page 75 will facilitate the understanding of the disassembly, as well as the assembly of the fuel injection pump, since it indicates clearly the order in which the component parts are fitted together to make a complete unit.

a. Place the pump in an inverted position in a vise, clamping the mounting flange between the vise jaws. It is advisable to use vise jaw guards made of soft metal, such as copper or aluminum, to protect the pump housing flange from being damaged or disfigured.

b. Press down the plunger guide cup with the thumb, and insert a service pin thru the hole provided for that purpose in the pilot of the pump housing. See Fig. 68, Page 75.

c. Remove the round split ring with the aid of a screw driver and a pair of flat nose pliers.

d. Press down the plunger guide cup again and remove the service pin.

e. The following parts can now be withdrawn from the pump housing, in the order given herewith: plunger guide cup, lower plunger spring seat, plunger spring, plunger and toothed control sleeve. The upper plunger spring seat automatically comes out with the control sleeve.

f. Place the pump in an upright position in a vise.

g. Unscrew the delivery valve holder with a socket, flat end or suitable box type wrench.

h. Lift out delivery valve spring and delivery valve.

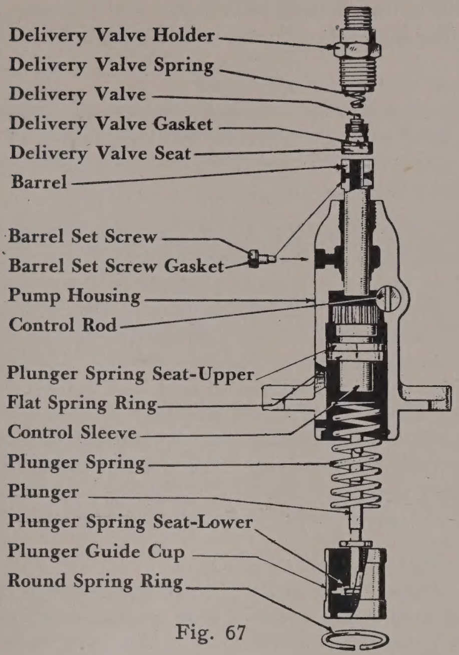

Delivery Valve Holder
Delivery Valve Spring
Delivery Valve
Delivery Valve Gasket
Delivery Valve Seat
Barrel
Barrel Set Screw
Barrel Set Screw Gasket
Pump Housing
Control Rod
Plunger Spring Seat-Upper
Flat Spring Ring
Control Sleeve
Plunger Spring
Plunger
Plunger Spring Seat-Lower
Plunger Guide Cup
Round Spring Ring

Fig. 67

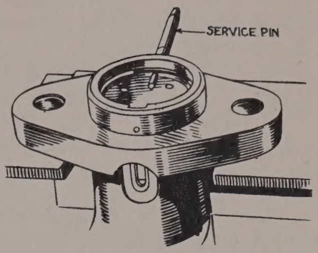

SERVICE PIN

Fig. 68

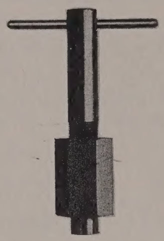


Fig. 69

i. Remove delivery valve seat with special extractor, TSE7682, shown in Fig. 69, by screwing the extractor to the threaded upper portion of the valve seat and then turning the hexagon nut of the extractor clockwise until the delivery valve seat is extracted.

j. Remove barrel set screw and its gasket.

k. Push up barrel from below and withdraw at top. NOTE: The barrel comes out readily but, occasionally, may stick slightly in the pump housing. In such cases, the lower end of the barrel should be tapped slightly with a piece of brass, copper, fibre or wood. Under no circumstances is it permissible to use a piece of steel, as considerable damage may result.

l. The control rod can now be readily withdrawn from its bore in the housing.

IMPORTANT: If several pumps are disassembled at one time, IT IS ABSOLUTELY NECESSARY that delivery valve seats and delivery valves, as well as plungers and barrels as taken from each pump, must be kept together. They are accurately mated parts and MUST NOT BE INTER-CHANGED.

2. Examination of Parts and When to Replace Them.— All parts must be washed carefully and thoroughly in clean fuel oil or gasoline and should be blown dry with compressed air. In the absence of compressed air, the parts should be allowed to dry as much as possible by themselves. The use of a soft cloth in drying parts is permissible only for those having no lapped surfaces. Plungers and barrels, as well as delivery valve assemblies, must be handled very carefully and their lapped surfaces should not be touched with the hands, as this invariably results in acid stains. Exceptionally dirty parts can be cleaned with paint remover. Plungers and barrels, as well as delivery valve assemblies which show a deposit of gum coming from the fuel oil should be soaked in acetone. Guiding remarks concerning the examination of each component part are given herewith:

a. Housing.— Insert control rod in the housing and check for excessive play. If this is observed, it will be necessary to replace the housing. From extensive experience, it can be said that this is rarely necessary.

b. Plunger Guide Cup.— This may show some wear in the outside bottom center, where the tappet screw of the engine's tappet mechanism bears against it. Unless this wear is so pronounced that only a little material remains, the guide cup need not be replaced. Should a guide cup be found to be cracked, it must of course be replaced with a new one.

c. Plunger and Barrel Assembly.— The plunger should be most carefully inspected for wear, preferably with the aid of a magnifying glass. If the lapped surface of the plunger has lost its mirror-like appearance and looks very dull or gray, it is a definite indication that there has been considerable wear, invariably due to dirt and abrasives in the fuel oil. Such wear, also referred to as erosion, is characterized by scratches and scuff marks, particularly on the upper portion of the plunger which covers the intake and by-pass ports of the barrel during operation. Plungers showing these symptoms MUST be replaced, as they are not usable. The edge of the plunger helix must appear sharp under the magnifying glass and should not show nicks or scuff marks which would adversely affect the metering of the fuel. Occasionally, plungers are found to have dark discolorations and pit marks on the lapped surface, which would indicate corrosion caused by the fuel oil containing destructive acids or water. In such cases, the grade of fuel oil and the engine filtering system should be investigated. Plungers showing corrosion or pit marks must be replaced, because they no longer have that accuracy of fit in the barrel necessary for the proper metering of the fuel.

d. Delivery Valve and Seats.— After the valve and seats have been thoroughly cleaned, they should be examined under a magnifying glass. The lapped surface of the under side of the valve seat, which contacts the lapped surface of the plunger barrel top, must be free from nicks and scratches and should not show corrosion pits. If either of these conditions is observed, both seat and valve must be replaced. The valve should not show scuff marks on either the relief piston or the conical seating surface. These indicate erosion and necessitate replacement of both valve and valve seat. After dipping the valve in clean fuel oil, it should readily fall into place in the valve seat bore. If it does not, some dirt is probably still present and the entire assembly should again be washed thoroughly in either clean fuel oil or gasoline. Should the valve appear to be sticky, despite repeated washings, it may be necessary to lap it slightly. For this purpose, a special compound is required. In an emergency, however, talcum powder mixed into a paste by adding a few drops of clean fuel oil can be used. UNDER NO CIRCUMSTANCES IS VALVE GRINDING COMPOUND TO BE EMPLOYED. Care must also be exercised that the lapping compound does not get on the conical seating surfaces of either valve seat or valve proper, as otherwise the seat might be damaged and result in difficulties due to leakage at these points. After lapping the valve, it should be carefully washed free of all traces of the lapping compound. It is a good practice to replace the delivery valve gasket, although if in good condition, it can be used again in an emergency.

e. Control Sleeve.— If the pinion teeth on the control sleeve are damaged or badly worn, these parts must be replaced. Replacement will also be necessary if the guide slots for the plunger cross-piece are badly worn.

f. Control Rod.— The teeth on the control rod rack section should be examined for wear. If this is found to be considerable, the control rod must be replaced to eliminate excessive play between the control rod rack and the control sleeve pinion. From experience, it can be stated that the control rod replacements are rarely required.

g. Plunger Spring.— The plunger spring should be free of nicks, scratches or pit marks, because any of these would weaken the spring and might cause untimely breakage. It is always advisable to replace springs of questionable appearance.

h. Spring Seats.— Replacement of these is only necessary if an examination discloses them to be distorted or badly worn.

i. Barrel Set Screw and Gasket.— It is always advisable to apply a new barrel set screw gasket when reassembling the pump. The screw itself need be replaced only if its threads are damaged, or the screw driver slot or square head is mutilated.

j. Delivery Valve Holder and Spring.— The holder should be inspected for damaged threads. The spring must be free from nicks, scratches or pitting, because any of these would weaken it and might cause breakage. It is always advisable to replace springs of questionable appearance.

NOTE: When it is necessary to order replacement parts, it is of importance that the complete type designation as engraved on the name plate of the pump be given, as this assists in definite identification.

3. To Assemble Fuel Injection Pump.— As already mentioned, the plunger and barrel as well as delivery valve and seat are mated parts and must not be interchanged. If several pumps are disassembled and reassembled at the same time, be sure to reinstall all component parts in the same pump housing from which they were removed. Before assembly, all parts should once again be rinsed in clean fuel oil and placed into the pump housing without drying.

a. Place the pump housing in an upright position in a vise by clamping the mounting flange between the vise jaws. It is advisable to use vise jaw guards made of soft metal, such as copper or aluminum, to protect the pump housing flange from being damaged or disfigured.

b. Insert the barrel thru the top in such a way that the vertical slot in its head faces the barrel set screw hole, as shown in Fig. 67, Page 75. Make sure the lapped surface at the upper barrel end is perfectly clean.

c. Screw in the barrel set screw, together with its gasket, and tighten firmly. The set screw end must engage in the vertical slot in the barrel head but must not cause binding of the barrel; it should only position the barrel in the housing and prevent it from turning. After the barrel set screw has been tightened, it should be possible to move the barrel up and down with the fingers.

d. Next insert the delivery valve seat, together with the delivery valve and its gasket, after making sure that the lapped surface on the under side of the delivery valve seat is perfectly clean.

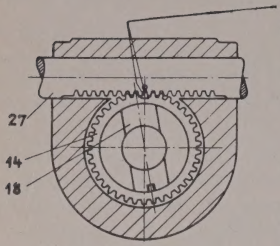
e. Insert the valve spring and then screw in the delivery valve holder, tightening the latter firmly with either socket, open end or suitable box-type wrench.

f. Place the pump housing upside down in the vise.

g. Insert the control rod in mid-position so that the assembly reference punch mark between the two center teeth of the rack is visible thru the bottom opening of the pump.

h. Slip the control sleeve over the barrel end and mesh with control rod so that the tooth of the control sleeve pinion, which is marked by an angular cut, indexes with the assembly reference punch mark of the control rod. See Fig. 70, Page 78.

i. Insert the upper spring seat.



Assembly Marks on Control Sleeve (14) must index with those on control rod (27)

Fig. 70

j. Insert the plunger spring, plunger and lower spring seat. The under side of the plunger cross piece, also referred to as a "yoke," has a notch ground into the bottom surface of the guide slot in the control sleeve. The notched side of the plunger cross piece must be engaged in the notched side of the control sleeve. The notch on the control sleeve and plunger will be on the side opposite to that on which the reference marking of control sleeve pinion and control rod are located. See Fig. 70.

k. Install the plunger guide cup, press it down and insert the service pin thru the hole in the pilot of pump housing. Press the split spring ring into the groove of the pilot, depress guide cup again and remove the service pin.

(6). Fuel Injection Nozzles and Nozzle Holders.— These fuel injection nozzles and nozzle holders are manufactured to precision accuracy, resulting in an assembly capable of long periods of uninterrupted service.

In outlining the procedure for inspection and cleaning, the necessity of cleanliness cannot be over-emphasized. A clean workbench, clean washing fluid containers, clean tools, and clean hands are all essential to produce satisfactory results. The use of suitable tools for this type of work is equally important.

If after a reasonable period of operation, it is deemed necessary to inspect and clean the nozzle, the following instructions should be used as a guide:

(a). To Remove Fuel Injection Nozzle and Holder From Engine.—

1. Before loosening any lines, apply kerosene or fuel oil freely to all connections, in order that dirt and grease may be removed.

2. Detach high pressure tubing and leak-off lines, covering their open ends with cloth or paper caps to protect against the entrance of dirt.

3. Remove the holding nuts and pull assembly from the engine, being careful not to strike the end of the nozzle against any hard surface. If the assembly seems to be stuck, rotate slightly to break it loose from carbon deposits within the cylinder head recess.

(b). To Disassemble and Clean Fuel Injection Nozzle and Holder.—

1. Wipe all dirt and loose carbon from the assembly with a clean cloth, free of lint.

2. Clamp the nozzle holder assembly in a vise and remove the nozzle cap nut. Remove the fuel injection nozzle.

3. Normally, the nozzle valve can be easily withdrawn from the nozzle body Fig. 71. However, in some cases it may be necessary to soak the nozzle in fuel oil, acetone, carbon-tetrachloride, or a similar carbon solvent, before removal is possible. Nozzles which cannot be readily disassembled should be returned to the manufacturer, where special hydraulic extracting equipment is available. Do not permit the polished surfaces of the nozzle to come in contact with any hard substance.

4. The nozzle valve can be cleaned with mutton tallow used on a soft cloth or a soft pad. The valve may be held by its stem in a revolving chuck during this operation. A piece of soft wood well soaked in oil, or a brass wire brush, will be helpful in removing carbon from the valve.

HARD OR SHARP TOOLS, EMERY CLOTH, CROCUS CLOTH, GRINDING COMPOUNDS, OR ABRASIVES OF ANY KIND SHOULD NEVER BE USED IN THE CLEANING OF NOZZLES.

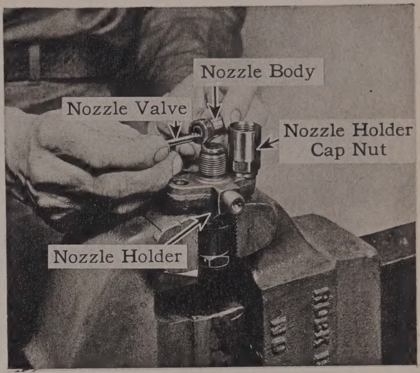


Fig. 71 — Disassembly of Fuel Injection Nozzle

5. The inside of the nozzle body can be cleaned by forming a piece of soft wood, well soaked in oil, the point of which will correspond to the angle of the nozzle valve seat. The orifice of the pintle type nozzle can be cleaned with a wood splinter.

The outer surfaces of the nozzle body may be cleaned with a soft cloth soaked in the carbon solvent. Do not attempt to scrape carbon from the surface around the orifice, as serious damage may result.

6. Thoroughly rinse both the valve and the nozzle body in clean fuel oil before reassembly. Lift the nozzle valve about ⅓ of its length out of the body. Valve should glide down again to its seat without aid when nozzle assembly is held at an angle of about 45°.

7. Thoroughly rinse the lapped end of the nozzle holder shank and the corresponding surface of the nozzle to assure clean seat between the surfaces.

8. Remove all carbon from the nozzle cap nut before reassembly.

9. Assemble the nozzle to the holder making sure that it is centered in the cap nut. To do this, screw the cap nut down as tight as possible by hand without the use of a wrench. Then slip the brass nozzle adapter over the nozzle to center the nozzle in the cap nut. Remove the nozzle adapter and tighten the cap nut down tight with a wrench.

(c). To Reassemble Fuel Injection Nozzle and Holder to Engine.—

1. Thoroughly clean the nozzle recess in the cylinder head before re-inserting the nozzle holder assembly. Particular attention should be paid to the seating surfaces, in order that no small particles of carbon will cause the assembly to be cocked or permit blow-by of the combustion gases. No hard or sharp tools should be used for this cleaning operation. A round piece of wood or brass properly shaped, is very effective.

2. The engine is provided with brass adapters in the cylinder head which act as seating surfaces for each nozzle holder cap nut. It is essential that there be no carbon flakes on the seating surfaces.

3. The assembly should be carefully inserted, in order that the nozzle tip does not strike against the recess wall.

4. The assembly securing nuts should be tightened evenly in order that there will be no cocking of the unit.

5. High-pressure lines and leak-off connections should be replaced and tightened.

6. If the performance of the engine still indicates difficulties with the nozzles, they should be removed and new nozzles installed.

(d). Nozzle Testing.— Every 1,000 hours of engine operation each fuel injection nozzle and holder assembly should be removed from the engine to check its opening pressure and spray pattern. A nozzle test stand is used to make these checks. These nozzles should have an opening pressure of 1800 pounds.

1. Warning.— Never place hands or fingers under a nozzle being tested. The penetrating power of the fuel under pressure is sufficient to puncture the skin and flesh and may cause blood poisoning. Therefore, HANDS MUST BE KEPT AWAY FROM A SPRAYING NOZZLE.

2. Checking Opening Pressure and Spray Pattern.— Install the injection nozzle and holder on the test stand and operate the hand lever rapidly for a few strokes with the pressure valve closed. This operation will permit the nozzle valve to definitely seat itself.

Open the pressure gauge valve and slowly raise the pressure until the nozzle opens. If the opening pressure is higher or lower than 1,800 pounds, make the necessary adjustments by turning the pressure adjusting screw in the injection nozzle holder clockwise if the opening pressure is to be increased; or counter-clockwise if the opening pressure is to be decreased. Repeat the above procedure until the 1,800 pounds opening pressure is obtained.

When the desired opening pressure has been obtained, slowly depress the hand lever of the test stand and observe whether, the nozzle remains tight up to approximately 1,500 pounds.

Turn the handle to close the pressure gauge and depress the operating lever rapidly in succession (at least 150 strokes per minute) and observe the nozzle spray pattern. If the nozzle functions correctly, the spray will be of closed formation and show no side streamers.

Nozzles which do not dribble at a pressure of 1,500 pounds and show a closed nozzle spray without side streamers at 150 strokes per minute possess the characteristics necessary for proper engine operation.

The following chart indicates the irregularities which may exist and gives their causes and remedies.

SERVICE ADJUSTMENTS

Irregularity	Cause	Remedy
1. Nozzle opening pressure too high:	a. Pressure adjusting screw set incorrectly. b. Nozzle valve seized in nozzle body.	Adjust pressure adjusting screw correctly and secure setting with its lock nut. Replace complete nozzle.
	c. Nozzle valve stuck in nozzle body due to coking.	See note "A".
2. Nozzle opening pressure too low:	a. Pressure adjusting screw incorrectly set.	Adjust pressure adjusting screw correctly and secure setting with its lock nut.
	b. Pressure adjusting screw broken or nozzle valve stuck in nozzle body due to coking.	Replace pressure adjusting screw. See note "A".

SERVICE ADJUSTMENTS — CONTINUED

3. Dripping of nozzle:	Nozzle valve leaking due to damaged seat or stuck valve on account of coking.	If valve seats are damaged, replace complete nozzle. Otherwise, see note "A".
4. Fuel spray distorted:	Nozzle tip coked or nozzle valve damaged.	If nozzle valve is damaged, replace complete nozzle. Otherwise, see note "A".
5. Nozzle fails to chatter:	a. Nozzle valve stuck or seized. Valve seat leaking.	If nozzle valve is damaged, replace complete nozzle. Otherwise, see note "A".
	b. Nozzle holder cap nut damaged internally thru frequent changing of the nozzle, causing nozzle to coke.	Replace nozzle holder cap nut.
6. Excessive overflow from leak-off connection of nozzle holder:	a. Too much play in nozzle valve.	Replace complete nozzle.
	b. Cap nut insufficiently tightened.	Tighten cap nut.
	c. Dust, grit or scale from tubing between the lapped surfaces of nozzle body and nozzle holder shank.	Remove nozzle and thoroughly clean the lapped surfaces with gasoline and compressed air.
7. Nozzle turns blue after service in engine:	Too little clearance around nozzle in cylinder head recess. Insufficient cooling.	Contact engine manufacturer or his agent for information regarding remedy. Also replace complete nozzle.

NOTE: Chattering of the nozzle valve noticeable when slowly operating the hand lever of the test stand indicates correct functioning of the nozzles.

NOTE "A": Soak nozzle in carbon tetrachloride, acetone, Bendix cleaner, Karbonoff or a similar non-corrosive cleaner and then remove loose carbon with a soft, dry cloth or brass wire brush.

(7). Relief Valve.— The relief valve at the end of the fuel injection pump header should be checked occasionally for sticking valve or broken spring. This may be done by removing the 9/16″ nut on the end of the valve and pulling out the valve and spring with the nut.

e. Lubricating Oil System.— If greatest importance for the successful operation of the engine is its proper lubrication. This means the constant supply and adequate pressure to all moving parts of good quality lubricating oil.

Normal lubricating oil pressure is between 25 and 50 pounds per square inch at normal speed and under load. If the engine operates below this point it should be shut down and the cause located. If new oil does not raise the pressure, it is usually an indication of worn bearings or leaking oil lines.

(1). Changing Lubricating Oil.— A lubricating oil change schedule must be developed and rigidly followed. We recommend that a complete oil change be made every 15 days or every 200 hours of operation.

To drain out the old oil open the drain that extends thru the right side of the engine subbase under its upper flange. Also open the drains in the bases of the cartridge type and metal edge type lubricating oil filters. We recommend that a new cartridge be installed in the cartridge type lubricating oil filter EVERY time the lubricating oil is changed in the engine. See paragraph (5) following.

Close all drains and pour about eight (8) gallons of fresh oil of the correct grade into the oil filler cup ahead of the flywheel housing near the instrument panel. Run the engine for about 10 minutes then shut the engine down and check the oil level by the dip stick. If necessary, add enough more fresh oil to bring the oil level to the indicated FULL mark.

Make certain the cap is replaced on the oil filler opening. This opening opens indirectly into the crankcase and protects against entrance of dirt and dust. It must be kept in place to keep the oil in the engine from this dirt and dust.

Between oil changes the oil level should be checked daily and should always be replenished before the LOW mark on the dip stick is reached. It should be kept as close to the FULL mark as possible. Makeup oil should be of the same viscosity and brand as that already in the engine. Do not mix two kinds of lubricating oil.

(2). Lubricating Oil Cooler.—

(a). Cleaning.— The oil cooler should be cleaned by flushing with fuel oil once every 2,000 hours of operation. This may have to be done more frequently depending on condition of the lubricating oil. Need for flushing will be made known by the lubricating oil temperatures increasing from day to day.

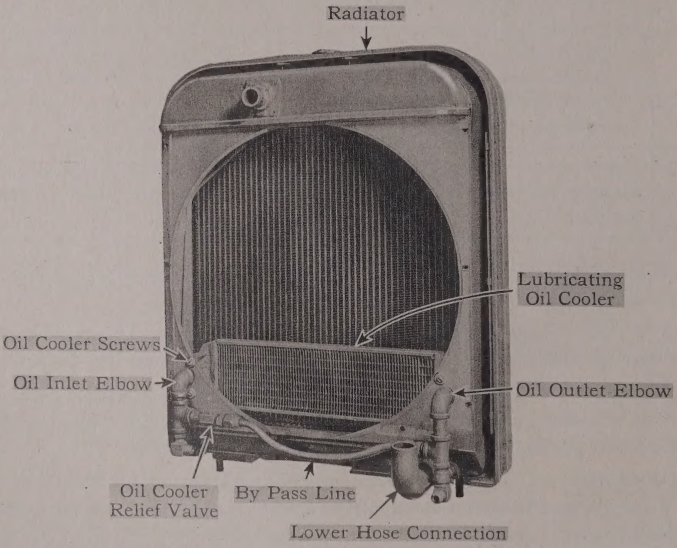


Fig. 72 — Lubricating Oil Cooler

In order to clean the oil cooler the radiator and oil cooler assembly should be removed from the engine as shown in Fig. 72.

When flushing out, the radiator should be placed on one side and the oil cooler flushed from top to bottom. Air pressure may be used after flushing to blow out any fuel that may be left in the cooler tubes.

(b). Removing Oil Cooler.—

1. Remove the lower water hose connection elbow by taking out the two cap screws that hold it to the radiator and lifting it off.

2. Hold the tubing fittings with one wrench and unscrew the tubing nuts on the lubricating oil by-pass line with a second wrench. The by-pass line may then be removed.

3. Unscrew both the inlet and outlet piping assemblies at the elbows by turning each complete assembly in a counter-clockwise direction.

4. Remove the four screws (two at each end) and slide the oil cooler section out.

(c). Oil Cooler Relief Valve.— At the same time the oil cooler is cleaned, the relief valve should also be cleaned. It is not necessary to disassemble this valve to clean it, simply flush with fuel oil and blow out with air.

The relief valve and the by-pass line should be reassembled to the oil cooler before replacing the radiator on the engine.

(3). Lubricating Oil Pump.— The lubricating oil pump screen and relief valve assembly should be removed and cleaned after every 1,000 hours of operation.

(a). Removal From Engine.—

1. Drain the oil from the engine and completely remove the drain pipe to prevent damage in subsequent operations.

2. Remove the oil temperature gauge thermocouple from the oil pan.

3. Disconnect the tubing from the metal edge type fuel filter, cartridge type fuel and lubricating oil filters. Remove these filters from the engine.

4. Remove the current-voltage regulator.

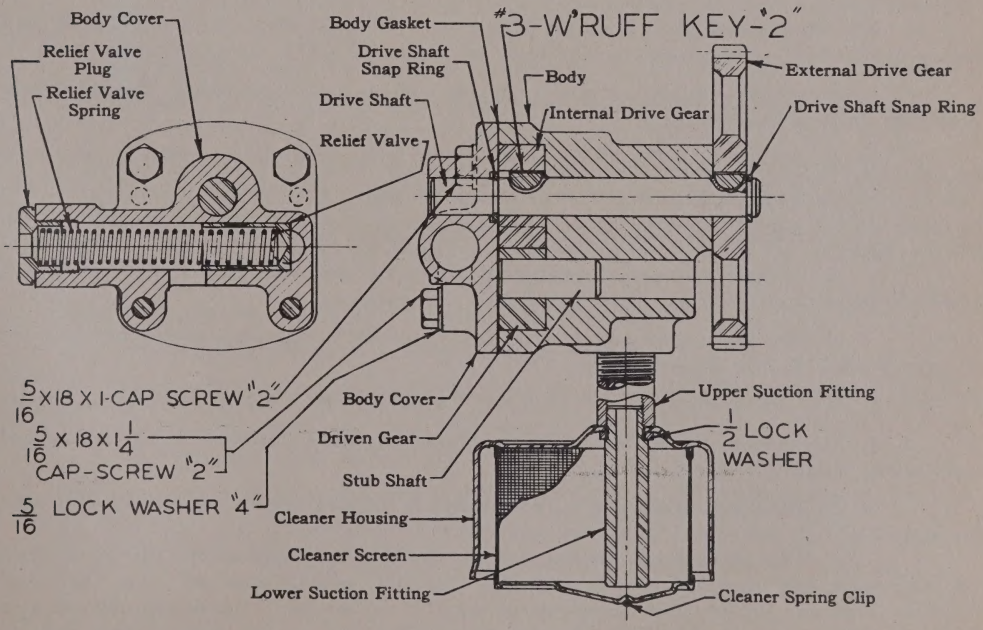

Body Cover
Relief Valve Plug
Relief Valve Spring
Body Gasket
#3-W'RUFF KEY-"2"
Drive Shaft Snap Ring
Body
External Drive Gear
Drive Shaft
Internal Drive Gear
Drive Shaft Snap Ring
Relief Valve
5/16 X 18 X 1-CAP SCREW "2"
5/16 X 18 X 1 1/4 CAP-SCREW "2"
5/16 LOCK WASHER "4"
Body Cover
Driven Gear
Stub Shaft
Upper Suction Fitting
1/2 LOCK WASHER
Cleaner Housing
Cleaner Screen
Lower Suction Fitting
Cleaner Spring Clip

Fig. 73 — Lubricating Oil Pump

5. Drop the oil pan by removing the bolts and cap screws which hold it to the engine crankcase and flywheel housing.

6. Cut the wires and remove the cap screws holding the lubricating oil pump to the cylinder block over the front main bearing.

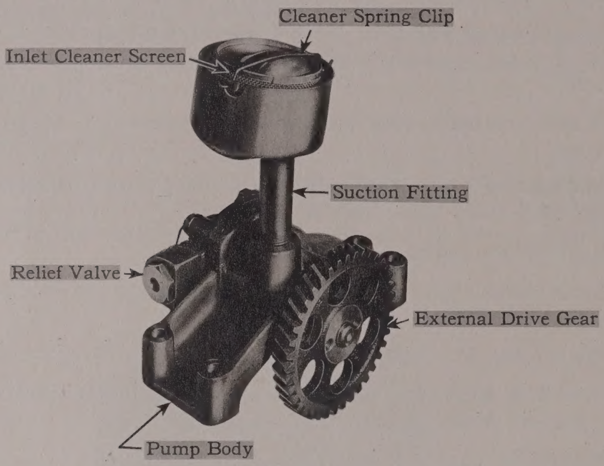


Fig. 74 — Lubricating Oil Pump

(b). Disassemble Lubricating Oil Pump.— See Fig. 73, Page 83 and Fig. 74. When it is necessary to completely disassemble the lubricating oil pump it should be done as follows:

1. Remove the cleaner spring clip and pull out the cleaner screen. The screen may be cleaned with kerosene or fuel oil.

2. Remove the relief valve plug spring and valve. Clean these parts in a similar manner.

3. Remove the end cover from the pump body.

4. Remove the snap ring from the drive shaft.

5. Using a gear puller, remove the drive gear and woodruff key from the shaft. Use the two (2) holes drilled and tapped in the gear for this purpose.

6. The drive shaft may now be pulled out; the snap ring removed and the internal drive gear pressed off with an arbor press.

7. The driven gear will fall out if the pump body is tapped on a piece of wood.

(c). Inspection of Parts.— All parts should be washed in kerosene or fuel oil, and inspected before reassembly.

If the filters and lubricating oil have been kept clean there should be very little wear on these parts.

Inspect the gears, shafts, and pump body for wear or rough spots. The radial clearance between the gears and pump body should not be less than .001″ or more than .004″. The endwise clearance between the gear and end cover should not exceed .002″ or less than a free fit when turned by hand. This may be adjusted by the thickness of the end cover gasket. If the gears, shaft or pump body should be badly worn or scored they should be replaced with new parts.

(4). Metal Edge Type Lubricating Oil Filter.— The care of this filter is identical to that already described for the metal edge type fuel filter.

(a). Turn the cleaning handle at least twice a day. If this handle is not turned often enough it will turn hard.

(b). Remove the drain plug in the bottom of the filter every 200 hours of operation and drain out all accumulated dirt and sludge.

CAUTION: Never attempt to use a wrench or other tool in an endeavor to disassemble the filter cartridge or to attempt to force the filter cleaning handle to turn.

(5). Cartridge Type Lubricating Oil Filter.— The filter cartridge should be changed every time the engine gets an oil change. This means the cartridge will be changed at least every 200 hours of operation.

Normally it is safe to assume that one cartridge will last the full 200 hours between oil changes. Regardless of this 200 hours, however, if the oil begins to darken or if a chemical analysis of the oil shows a Precipitation No. of more than .06 or a Neutralization No. of more than .3 the filter cartridge should be changed immediately. To change the cartridge proceed as follows:

(a). Shut down the engine.

(b). Remove the drain plug in the base of the filter and allow the oil to drain out of the filter.

(c). Unscrew the cover capscrew and remove the cover assembly.

(d). Remove and discard the used filter cartridge.

(e). Clean all parts of the filter.

(f). Install a new cartridge making sure the cover gasket is in good condition and that the cover is drawn tight.

(g). Run the engine for about 10 minutes and then inspect the filter for leaks.

(h). Shut the engine down and check the oil level by the dip stick. Add enough oil to compensate for the oil required to fill the filter body and saturate the filter cartridge.

f. Air Intake System.— Air filters are provided on the engine to remove the dust and dirt which would otherwise be pulled into the engine, increasing cylinder wear by its abrasive action. Keep the filters clean; if they are allowed to stop up with dirt, insufficient air will pass into the combustion chambers to support combustion of the injected fuel. This will result in an over-rich mixture of fuel causing the exhaust to be smoky and the engine to lose power.

(1). Never run the engine with the air cleaner disconnected.

(2). Never run the engine with the air cleaner stopped up.

(3). Each day before running the engine clean the air cleaner oil cups and fill with oil to the level of the bead.

(4). Use fresh lubricating oil like that used in the crankcase of the engine.

(5). Never attempt to remove the filtering elements from the air cleaners.

(6). The filter element should be cleaned every 300 hours. This is accomplished by removing the entire air cleaner from the engine and flushing with gasoline or kerosene.

g. Exhaust System.—

(1). Exhaust Manifold.— The exhaust manifold should require no service except cleaning the water passages occasionally. To do this the manifold must be removed from the engine. This may be done as follows:

(a). Drain the cooling system.

(b). Disconnect the flexible exhaust pipe from manifold at the flange.

(c). Remove the ½" tubing line between the cylinder block and the manifold.

(d). Remove the ½" tubing line between the exhaust manifold and the water outlet manifold.

(e). Take off the exhaust manifold by removing the 6 cap screws and lifting the manifold off. If necessary, the manifold can be rested on the air cleaner glands during the lifting-off process.

(2). Exhaust Silencer.— The spark arrestor will operate at the utmost efficiency if cleaned at least every 200 hours. This can be done in the following manner.

(a). Remove the carbon collector which extends below the bottom of the spark arrestor and dispose of the collected carbon. This is done by loosening the bolt at the bottom of the collector.

(b). To clean the interior of the silencer, all handhole covers should be removed and accumulated carbon scraped out. Interior cleaning of the silencer probably will not be required more frequently than every 1,000 hours, unless the carbon deposits are of an oily type.

h. Cylinder Head.— The cylinder head should need no service except when it is necessary to grind valves or for a major overhaul at approximately 4,000 hours.

(1). Cylinder Head Removal.—

(a). Drain the cooling system.

(b). Detach the exhaust pipe and remove the exhaust manifold.

(c). Loosen and remove the acorn nuts on top of the cylinder head cover. Using a babbit hammer tap the corners of the cover with an upward motion. Take a screwdriver and pry the cover loose using the base of the L on DIESEL (cast on cover) as a prying point. This is done to keep the screwdriver from ruining the cover gasket and thus will allow the gasket to be used again. Fig. 75, shows valve cover removed.

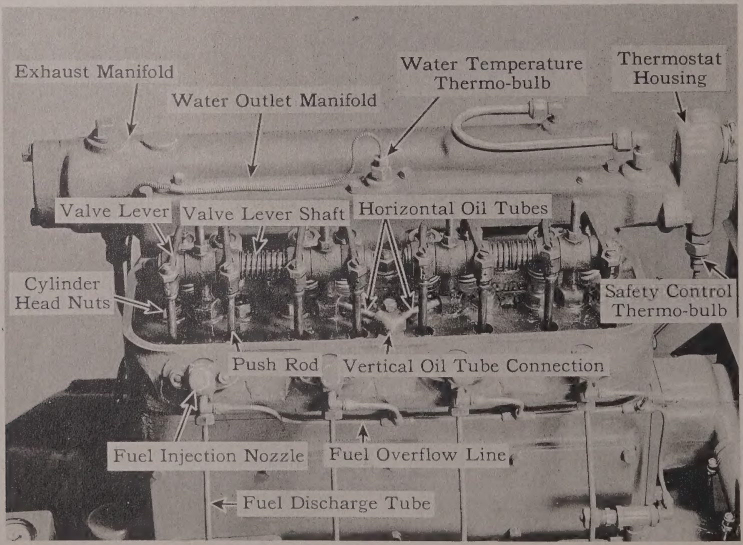

Exhaust Manifold
Water Outlet Manifold
Water Temperature Thermo-bulb
Thermostat Housing
Valve Lever
Valve Lever Shaft
Horizontal Oil Tubes
Cylinder Head Nuts
Safety Control Thermo-bulb
Push Rod
Vertical Oil Tube Connection
Fuel Injection Nozzle
Fuel Overflow Line
Fuel Discharge Tube

Fig. 75 — Cylinder Head — Cover Removed

(d). Remove the valve lever assembly, push rods and valve stem caps.

(e). Remove the thermostat housing.

(f). Remove the water outlet manifold.

(g). Remove the air cleaner gland assemblies. It is not necessary to detach the cleaner from the gland, simply remove the single capscrew in each gland and pull each assembly off.

(h). Remove the injection nozzles and lines. If all the brass nozzle adaptors do not come out of the head these can be driven out from the under side after the head is off the engine.

(i). Remove the 15/16″ cylinder head nuts. Using a soft hammer, tap the corners of the cylinder head with an upward motion. Care should be taken not to hit the cylinder head too hard. The cylinder head can now be lifted off the block.

(2). Disassemble Cylinder Head.—

(a). Remove the valves and springs. This is done by compressing each spring (one at a time) and removing the two piece valve spring lock, and the spring cap and spring. The valve can now be removed. If the valves are to be returned to the head it is a good practice to keep them in such order that they can be returned to the original port. Fig. 76.

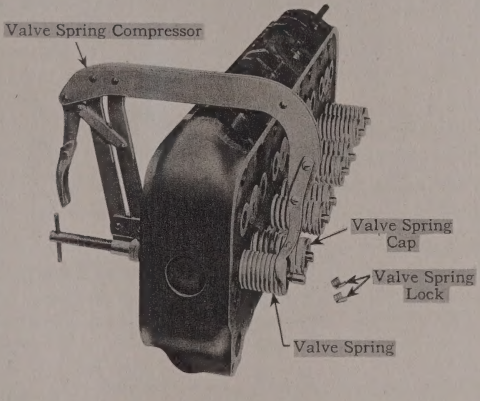


Fig. 76 — Disassemble Cylinder Head

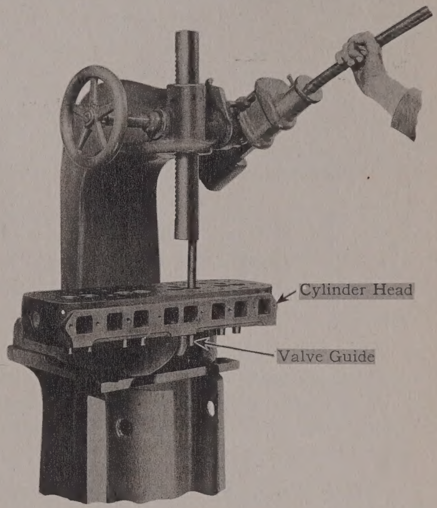


Fig. 77 — Remove Valve Guide

(b). Remove the injection nozzle adaptors and fuel cups (precombustion chambers). This may be done by turning the head bottom side up and tapping them out with a soft brass bar or a hard piece of wood.

(3). Valve Guide Repairs.— If the valve guides are worn excessively they should be replaced. If the valves have had the proper care, however, the valve guides should not need replacement before about 8,000 hours.

(a). Replacing Valve Guides.— The valve guides can be pressed out with a small arbor press, using a small bar to press on the guide. If an arbor press is not available, the guides can be driven out with a soft brass bar. Fig. 77.

To replace the valve guide, place the cylinder head face down on the arbor press or on a wood bench. Start the guide straight in the guide hole with a few light taps with a hammer, then press the guide down tight against the shoulder. See Fig. 78. Ream the guide in place with a ⅜" hand reamer.

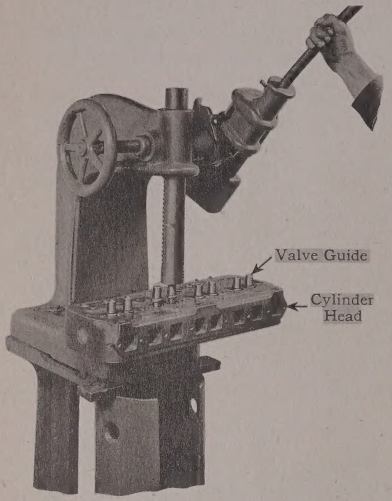


Fig. 78 — Install Valve Guide

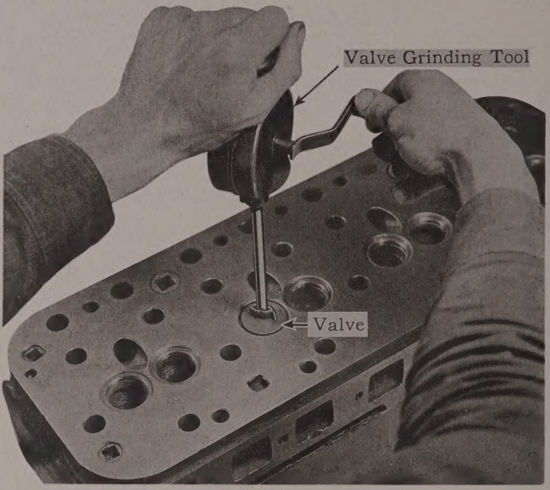


Fig. 79 — Valve Grinding

(b). Grinding Valve Seats.— After the valve guides have been reamed, the valve seats should be refaced with a 45° valve seat grinder. The valve seats cannot be reseated with an ordinary reseating tool as they are hardened inserts. Check the valve seats with an indicator as shown in Fig. 80, Page 89. The indicator should not run out more than .002".

(4). Valve Grinding.— Clean the valves and guides by scraping off all the carbon and then polish with fine emery cloth. Be sure to remove all trace of the emery residue. If the valves have only slight ridges at the edge of the seat they may be refaced. If the outer edge of the valve is less than 1/32" thick after refacing, it should be replaced with a new valve. Thin edges on the valve overheat and cause the valve to warp.

Insert valves in the cylinder head and be sure they are free in the guides. Remove one valve and coat lightly with grinding compound and insert in cylinder head. Insert valve grinding tool in the holes provided, and rotate 30 or 40 turns, lifting the valve occasionally to prevent ridging. See Fig. 79. Remove the valve and wipe the grinding compound from valve face and seat. CLEAN THOROUGHLY.

Examine the valve seat and valve face for pits or irregularity. Proper seating can be checked by making light, soft pencil marks across the valve face at intervals and then rotating the valve under pressure part of a turn. The rubbing or smearing of all pencil marks indicates proper seating. If seats are not smooth and show improper seating, repeat the grinding operation until valves seat properly as indicated above.

After thorough cleaning of all parts, oil the valve stems and seats and reassemble the cylinder head.

The injection nozzle ports should be stuffed with paper, to prevent foreign material being dropped in on top of the pistons, until actual time to install the injection equipment during reassembly.

(5). Assemble Cylinder Head to Cylinder Block.— When assembling cylinder head to cylinder block there are several points that should be carefully watched.

(a). The face of the head and the top of cylinder block should be thoroughly cleaned.

(b). Install all new rubber grommets and copper gaskets.

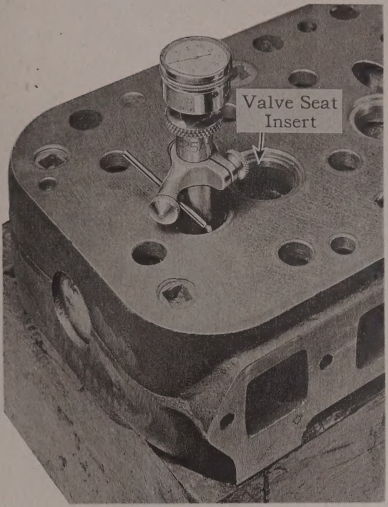


Fig. 80 — Checking Valve Seats

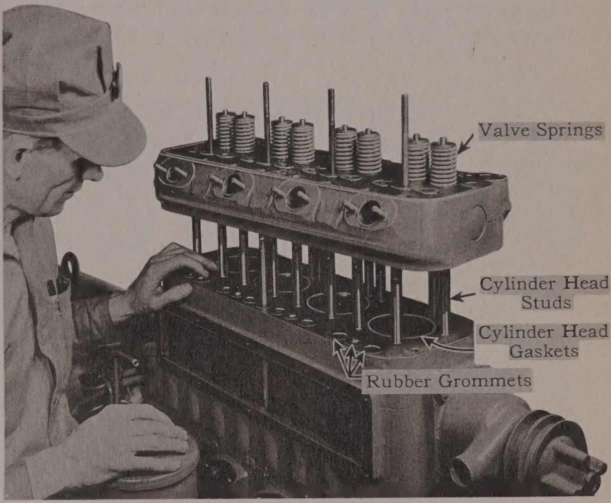


Fig. 81 — Inspection Before Installing Cylinder Head

(c). Place cylinder head on top of the studs, then examine top of the cylinder block to be sure no dirt has fallen out of the head and that all gaskets are in place. See Fig. 81.

(d). Drop the cylinder head down in place over the studs. Put a few drops of oil on each stud, put the nuts on and pull them down evenly to 130 to 135 ft. lbs. on torque wrench.

(e). Replace the valve lever assembly and the remainder of the parts that have been removed during cylinder head removal.

(f). The acorn nuts on the cylinder head cover should be pulled down snug. Do not tighten too much, however, as there is a possibility of cracking the cover.

(g). The pre-combustion chambers (fuel cups) and brass injection nozzle adaptors should not be installed in the cylinder head until the head is on the engine and ready for the addition of the injection equipment. If these were installed in the cylinder head and some one should accidentally press the starter push button with the batteries connected, these parts would be shot from the cylinder head with killing force.

i. Valve Lever Assembly.—

(1). Remove Valve Lever Assembly from Cylinder Head.—

(a). Remove the cylinder head cover.

(b). Remove the 5/16″ capscrew that holds down the oil tube connection. This is about in the center of the head lengthwise.

(c). Loosen and remove the 3/8" nuts holding the assembly to the head.

(d). Using a screw driver pry the oil tube connection loose from the vertical oil tube. This tube comes up from the block thru the head and furnishes lubricating oil to the rocker arms.

(e). Lift the entire valve lever assembly off the head being very careful not to twist the oil tubes in the oil tube connection. See Fig. 82. This connection is easily damaged and if bent or loosened to a material degree, it could cause leaks in future engine operation. Be careful not to lose the valve stem caps which are now found loose; one on the top of each valve stem.

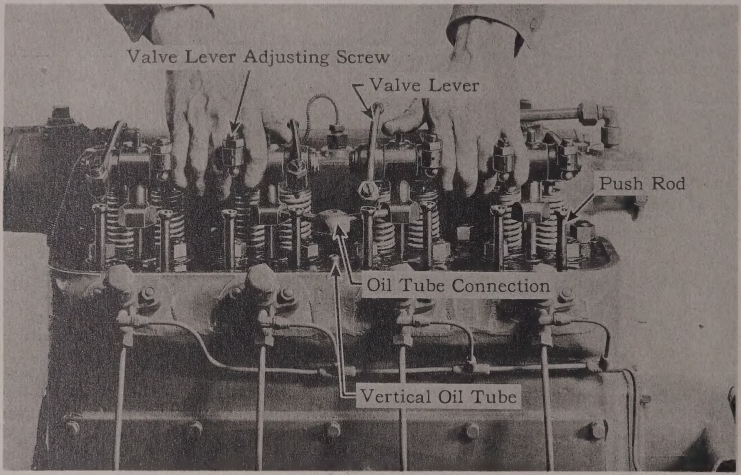


Fig. 82 — Remove Valve Lever Assembly

(f). Remove the push rods.

(2). Disassemble Valve Lever Assembly.—

(a). The valve lever assembly is broken up into its two major parts by removing the horizontal oil tubes. This is done by taking the complete assembly and placing one of the horizontal oil tubes in the corner of a vise while supporting the one end of the valve lever assembly with your hand. See Fig. 83, Page 91. With the assembly in this position, tap the valve lever bracket into which the vise held horizontal oil tube extends, thus disconnecting the horizontal oil tube at this point.

Now place the other horizontal oil tube in the vise and tap the rocker arm bracket into which it extends.

The entire above procedure now leaves two separate valve lever shaft assemblies and the V-shaped horizontal oil tube connection which was removed from between them.

(b). To disassemble either of the above two valve lever shaft assemblies you must first place it in a vise and pry off the two valve lever snap rings (one at each end of shaft), using a screwdriver to spread the split portion of each ring. Care should be taken as these rings fly off with some force.

(c). The valve levers, brackets and springs can now be slid off the shaft. Great care should be taken to keep each part in order as it comes off the shaft. These parts should not be mixed up.

(3). Inspection of Parts.— Clean all parts thoroughly and inspect them for wear.

(a). Inspect the shaft for clogged oil holes. These may be cleaned by washing in kerosene or fuel oil and blowing with air.

(b). Inspect the valve lever bushings for wear. The bushing clearance to the shaft should be .001″ minimum and .0015″ maximum for new parts. A clearance of .005″, however, is permissible in a worn engine. If it is more than this the bushings should be replaced. If new bushings are pressed into the valve lever, it will be necessary to ream them to the above clearance.

(c). Clean the parts thoroughly and reassemble. A method of installing the snap rings is shown in Fig. 84.

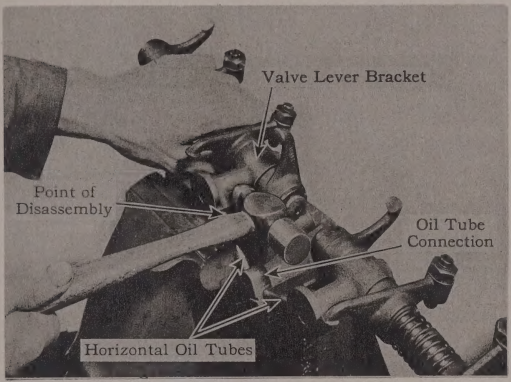


Fig. 83 — Disassemble Valve Lever Assembly

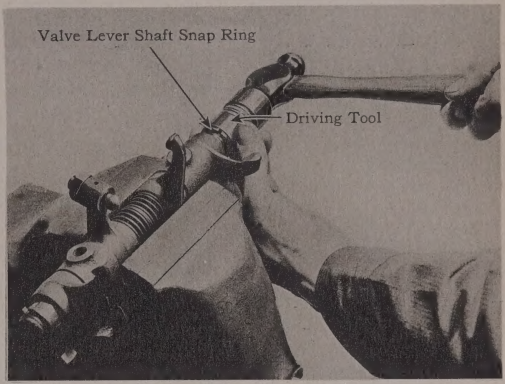


Fig. 84 — Assemble Valve Lever Shaft Assembly

(4). Install Valve Lever Assembly to Cylinder Head.—

(a). Replace the push rods and valve stem caps.

(b). Place the valve lever assembly on the studs, and make certain the horizontal oil tube connection will line up with the vertical oil tube which comes up thru the cylinder head. Care should be taken not to drive the vertical oil tube down into the cylinder block. If the vertical oil tube is driven any lower than its original height the connection it makes with the horizontal oil tube connection block will leak.

(5). Valve Adjustment.— After the valve lever assembly has been tightened down, adjust the valves to .015″ clearance as shown in Fig. 85, Page 92. The final adjustment can be made more accurately when the engine is running. To do this proceed as follows:

(a). Run the engine at approximately 350 revolutions per minute and let it warm up thoroughly.

(b). Loosen the adjusting screw, and with a screw driven turn the adjusting screw in or out until a .012″ thickness gauge will just slide between the valve lever end and the valve stem cap with a slight drag. Tighten the lock nut and recheck the clearance. Repeat the above procedure until there is just a slight drag on the gauge when the lock nut is tight. Then proceed with all valves as outlined above.

(c). Pour about one pint of clean oil over the valve mechanism, and replace the cylinder head cover.

j. Camshaft.—

(1). Removal.— If it should be necessary to remove the camshaft for inspection or replacement, it may be done as follows:

(a). Drain the cooling system and remove the radiator and fan.

(b). Remove hand crank assembly including the hub on the crankshaft.

(c). Remove the valve lever assembly and push rods.

(d). Remove the V-belt adjusting strap from the charging generator and remove the V-belts.

(e). Loosen the two ⅜″ Allen set screws in the crank sheave and remove this sheave with a puller. See Fig. 86.

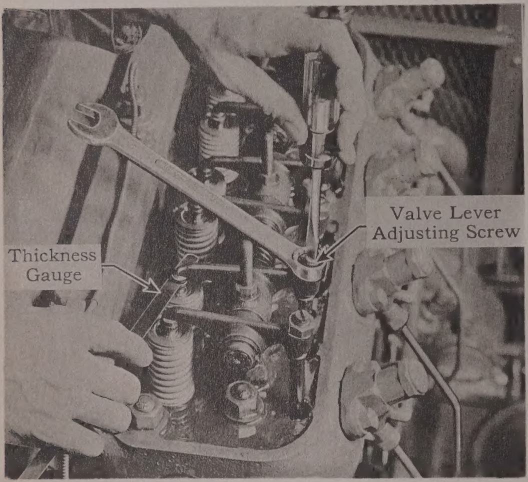


Fig. 85 — Valve Adjustment — Cold

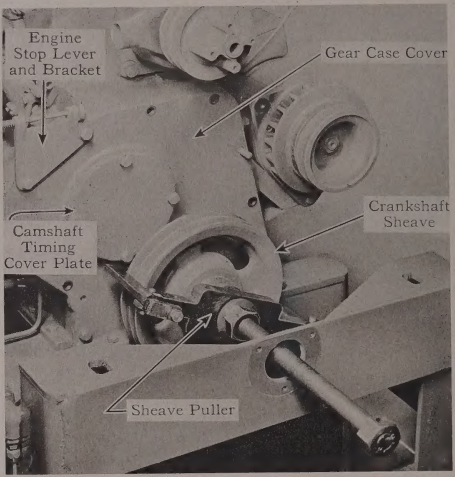


Fig. 86 — Pulling Crankshaft Sheave

(f). Remove the engine stop lever and bracket assembly.

(g). Remove the gear case cover by taking out its cap screws along with the two bolts thru the governor housing flange. This gear case cover can be driven off by hitting the edge of the cover beside the two points where it is doweled to the block. The cover sticks out slightly at these two points making this possible.

(h). Remove the small hand hole plate on the right side of the cylinder block.

(i). Remove the fuel injection pumps and tappets. Do this as follows:

1. Disconnect the fuel discharge tubing from the fuel injection pump and injection nozzles. CAUTION: Cover the discharge fittings on the injection pumps to prevent dirt from entering.

2. Disconnect the fuel tubing at each end of the fuel header.

3. Disconnect the governor from the fuel pump governor control rod and remove the governor from the engine.

4. Remove the 5/16″ capscrews holding the fuel injection pumps to the cylinder block and lift all the pumps off at one time. CAUTION: Do not lose any of the copper shims that are found under the injection pump. These shims should be kept separate and in such order that they can be replaced under the same pump from which they were removed. Then remove the fuel injection pump tappets and valve tappets from the engine. See Fig. 87.

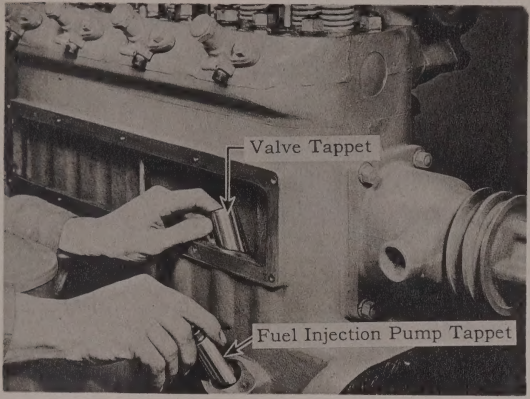


Fig. 87 — Removing Tappets

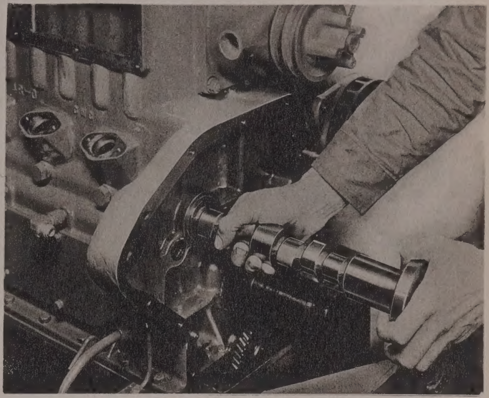


Fig. 88 — Removing Camshaft

(j). Disconnect the fuel suction and discharge tubes from the fuel transfer pump and remove the fuel transfer pump by taking out the two cap screws holding it to the cylinder block.

(k). Remove the front oil slinger on the crankshaft by using two large screw drivers, one on each side. Be very careful not to bend or damage the slinger. If damaged it must be replaced by a new oil slinger when reassembled.

(l). Remove the camshaft gear by taking out the four capscrews holding it to the camshaft and pulling the gear forward off the camshaft.

(m). Care should be exercised when removing the camshaft. Support the camshaft as shown in Fig. 88 and keep the camshaft aligned with the bearings while it is being pulled out, otherwise the camshaft bearings may be damaged.

(2). Replace camshaft and time valves.— Before replacing the camshaft, all parts should be cleaned with kerosene or fuel, and the cams and bearing surfaces inspected for wear.

(a). Replace the camshaft being careful not to damage the bearings. If the bearings are damaged, the engine must be dismantled and turned bottom side up as described under the crankshaft maintenance section.

(b). Replace the camshaft gear with the timing mark on the camshaft gear between the two marks on the crankshaft gear. See Fig. 89, Page 94. One of the cored holes in the camshaft gear is nearer the center of the gear than the other three. The tapped holes in the camshaft are positioned likewise. Match the off-center hole in the camshaft gear with the corresponding hole in the camshaft. Put the capscrews in and tighten them up. The final adjustment of the valve timing is done as described under "Injection Pump Timing."

(c). Install the oil slinger by heating it to a dull red and placing it on the crankshaft with the flat side against the crankshaft gear.

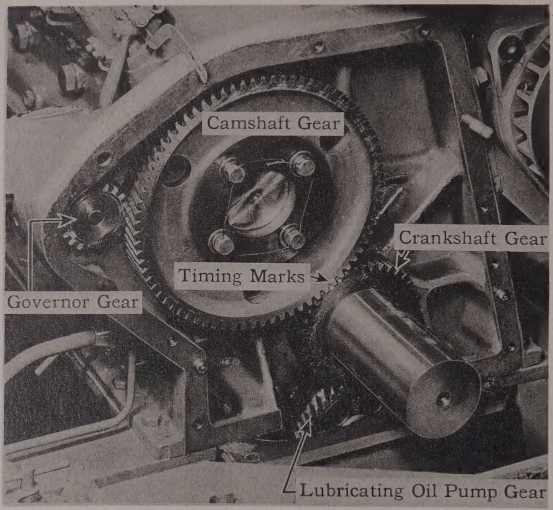


Fig. 89 — Gear Train Assembly

(d). Replace the fuel transfer pump, fuel injection pumps and connect up the fuel lines. Be sure the proper amount of shims are under each fuel injection pump as stamped under the engine number on the gear case. Then proceed at this point to time the engine as outlined under "Fuel Injection Pump Timing."

(e). The remainder of the parts removed from the engine may now be replaced.

k. Piston and Connecting Rod.—

(1). Replacing Connecting Rod Bearings.—

(a). Remove the large hand hole plate on the left side of the crankcase by removing the charging generator end bracket, the flexible tubes and wires from the filterette, and the capscrews holding the hand hole plate to the engine.

(b). Remove the large cartridge type lubricating oil filter and the small hand hole plate on the right side of the engine.

(c). Remove the cotter pins from the heads of the castle nuts on the lower part of the connecting rod. Remove the nuts and detach the connecting rod cap. If more than one cap is removed, be certain not to mix them up. They must be reinstalled on the same rod and in their original positions. Each connecting rod and connecting rod cap is numbered. These numbers must be on the same side of the connecting rod when it is put back together.

(d). Remove the bearing half from the detached section of the rod. Turn the crankshaft so the upper part of the connecting rod can be moved to one side and its bearing half removed.

(e). Before installing new connecting rod bearings, clean the surfaces of the connecting rod on which the new bearings will fit. Clean the crankshaft section on which the bearing will rest. Put a liberal amount of lubricating oil on the bearing surface of the crankshaft and also on the lower half of the connecting rod bearing before assembly. In assembly be certain that the heads of the connecting rod bolts are seated properly and that the nuts are pulled up by a torque wrench to 90-95 ft. lbs. Always use new cotter pins when keying the connecting rod bolt nuts in place.

(2). Removing Piston and Connecting Rod.—

(a). Drain the cooling system.

(b). Remove the cylinder head.

(c). Remove the two handhole plates (one on each side of the engine) and the lower half of the connecting rod as described in above paragraphs.

(d). Remove the carbon around the inside of the cylinder liner at the top with a scraper. Push the piston out of the top of the cylinder until it rests its weight on the bottom oil ring. Cover the crankshaft with a cloth or shop towel to prevent damage. Remove the two piston pin lock rings with a pair of pliers and drive out the piston pin with a soft brass bar. See Fig. 90. CAUTION: Do not remove the brass bar from the piston and connecting rod until the crankshaft is in position to remove the connecting rod as outlined below.

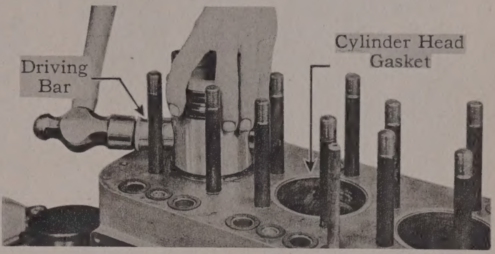


Fig. 90 — Driving Out Piston Pin

(e). Turn the crankshaft until the crank throw is horizontal and toward the smaller of the two handholes. Reach thru the large handhole and while holding the connecting rod with one hand, remove the brass bar from the piston, and lower the connecting rod into the bottom of the oil pan. Pull the top of the connecting rod out thru the large handhole and lift it out.

The piston may now be lifted off the cylinder block.

(3). Inspection of Parts.—

(a). Piston.— Clean the piston thoroughly — a carbon solvent, such as carbon tetrachloride may be used. If no carbon solvent is available the pistons may be cleaned by using steel wool dipped in water. Scrape out any accumulated carbon inside the piston and clean out all the oil return holes in the oil ring grooves. Inspect the pistons for cracks and rough spots on the sides of the ring grooves. If the piston is cracked or ring grooves show excessive wear it should be replaced. Under normal conditions the pistons, if not damaged, may be used indefinitely even though the cylinder liners are replaced as there is very little wear on the pistons.

(b). Piston Rings.— When installing a new piston, always use new piston rings. If the same piston is used, new rings should be installed if worn excessively or at major overhaul periods.

When installing new rings, the end gap should not be less than .015″ or more than .020″. The side clearance in the ring grooves not less than .0015″. This applies to all rings.

(c). Piston Pin and Bushing.— Wash the piston pin in kerosene or fuel oil and inspect for excessive wear or cracks.

When installing piston pin it should have .0000″ clearance in the piston and .0015″ to .003″ clearance in piston pin bushing. CAUTION: Do not ream the piston pin holes in the piston.

When replacing the piston pin bushing, it may be pressed out in an arbor press using an arbor 1⅜″ in diameter. Press a new bushing in place and ream to .0015″ larger than piston pin.

(d). Connecting Rod.— Clean the connecting rod with kerosene or fuel oil and make certain the drilled passage to the piston pin bushing is clean by blowing out with air.

(4). Installing Piston, Piston Pin and Connecting Rod.—

(a). Insert the connecting rod thru the hand hole into the lower part of the cylinder bore. Hold in this position.

(b). Place the piston over the upper part of the connecting rod and tap the piston pin back into place. Be careful not to damage the bushing in the connecting rod. If this happens the pin will not be free and must be driven out again in order to clean up the burr.

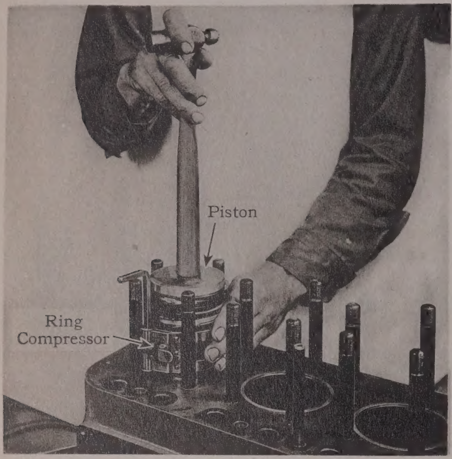


Fig. 91 — Install Piston in Cylinder Block

(c). Install the two piston pin snap rings. These keep the pin from making contact with the cylinder wall.

(d). At this point be certain the gaps in the rings of each piston do not come directly over each other. They should be off-set so there will be a perfect seal. It is well to place a little lube oil on the rings as the piston will slide back into place easier.

(e). Using a piston ring compressor, compress the bottom oil ring on the piston and tap the piston down with a hammer handle. Fig. 91. Use great care in this operation. Loosen the ring compressor and push the piston down so that the compressor covers all four remaining rings. Tighten the compressor and tap the piston down as before.

(f). Reinstall connecting rod on crankshaft.

(g). Re-assemble the engine.

I. Cylinder Liners.— If given the proper lubrication and care, the cylinder liner wear will be very small.

No set rule can be established on the amount of wear permissible before a liner change is necessary — the engine performance will be the best guide in this direction. If it should be necessary to replace a liner it may be done as outlined below. CAUTION: The cylinder liners are made of hardened alloy cast iron, and should be handled with care when being removed or replaced. Because of their hardness, they are relatively brittle and a sharp crack against any hard surface could fracture the liner.

(1). Removing Cylinder Liner.—

(a). Drain the cooling system.

(b). Remove the cylinder head.

(c). Remove the piston and connecting rod.

(d). Refer to Figs. 92 and 93, Page 97. Remove parts (A) and (B) from part (E). Place part (F) on top of the cylinder block over the liner that is to be pulled. Unscrew the ¾″ U.S.S. nut on top of part (E) until it is near the top end of the threads. Place part (C) on part (F) as shown and place part (E) thru the drilled hole in part (C) until it rests on the thrust bearing. Place part (A) thru the handhole door and be sure it is centered in the lower end of the cylinder liner. Screw part (E) into the threaded hole in the center of part (A) until the end is flush with the bottom. Screw the ¾″ nut down until all the slack is out. With a suitable wrench, turn the ¾″ nut down until the liner is pulled free from the cylinder bore.

(2). Installing Cylinder Liner.—

(a). The liner is installed in the cylinder with the same tools as used for removing except for leaving off part (F) and using part (B) as shown in Figs. 92 and 94, Page 97.

The liner and cylinder bore should be cleaned thoroughly and the outside of the liner oiled with light oil before attempting to pull it into the cylinder block. Before the liner is pulled the last ½″,

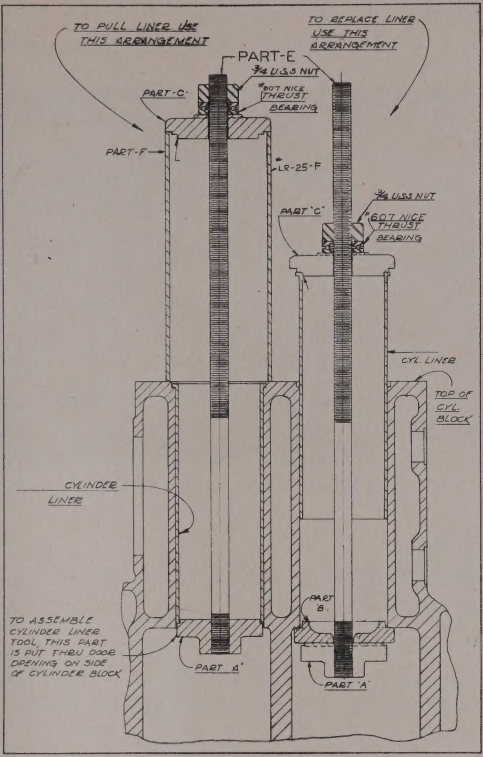

TO PULL LINER USE THIS ARRANGEMENT
TO REPLACE LINER USE THIS ARRANGEMENT
PART-E
¾ U.S.S NUT
PART-C-
#607 NICE THRUST BEARING
PART-F
LR-25-F
¾ U.S.S NUT
PART "C"
#607 NICE THRUST BEARING
CYL. LINER
TOP OF CYL. BLOCK
CYLINDER LINER
TO ASSEMBLE CYLINDER LINER TOOL, THIS PART IS PUT THRU DOOR OPENING ON SIDE OF CYLINDER BLOCK
PART "B"
PART "A"
PART "A"

Fig. 92 — Pulling and Replacing Cylinder Liners

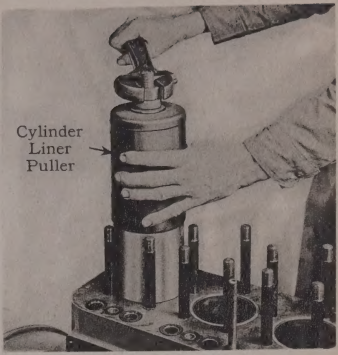

Cylinder Liner Puller

Fig. 93 — Remove Cylinder Liner from Block

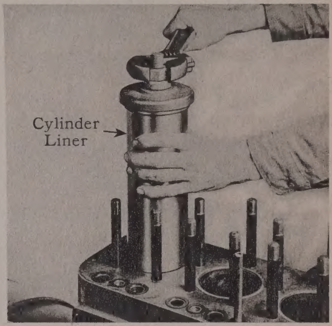

Cylinder Liner

Fig. 94 — Install Cylinder Liner in Block

care should be taken to be sure there is no dirt or foreign matter in the cylinder block counter-bore. If any dirt is left under the shoulder of the liner the top of the liner may be broken off.

(b). Reassemble the engine.

m. Crankshaft and Bearings.—

(1). Main Bearing Service.— All of the main bearing load of these engines is carried on the lower main bearing halves only. Any scoring or over-heating of the main bearing halves can therefore be observed by removing the main bearing caps one at a time. Due to the fact that no load is imposed on the upper main bearing half, these halves may not require changing as often as the lowers.

When removal of the main bearing shells becomes necessary and the removal of the crankshaft is undesirable, each lower main bearing half may be removed by taking off its bearing cap. The upper main bearing half can be rolled out with the aid of a driving tool as shown in Fig. 95, Page 98. For a good job, however, we recommend crankshaft removal, if it is necessary to replace all main bearing halves. Fig. 96, Page 98 shows the rear thrust collars correctly in place.

(2). Remove Crankshaft From Engine.—

(a). Drain the cooling and lubricating oil systems.

(b). Detach the flexible exhaust pipe at the engine.

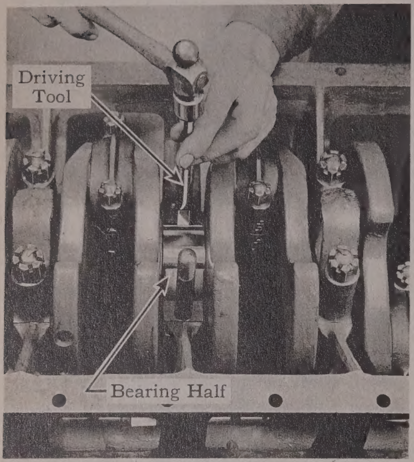

Driving Tool
Bearing Half

Fig. 95 — Rolling Out Main Bearing

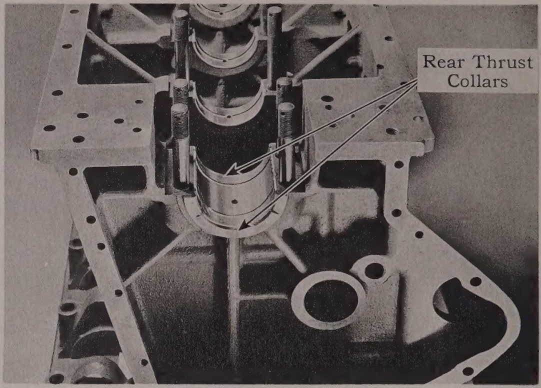

Rear Thrust Collars

Fig. 96 — Rear Thrust Collar Detail

(c). Disconnect the fuel supply and fuel return lines at the engine.

(d). Remove the hand hole plates from both sides of the main generator by taking out the four round head screws in each plate. Disconnect the main generator and exciter leads.

(e). Remove the bolts that hold the main generator to the subbase. Remove the shield of the main generator cooling fan just back of the flywheel housing. Remove all the cap screws that fasten the main generator to the flywheel housing. See Fig. 97.

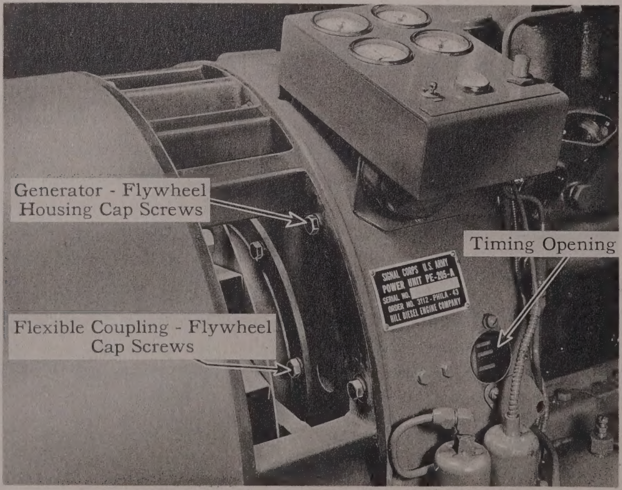

Generator - Flywheel Housing Cap Screws
Timing Opening
SIGNAL CORPS U.S. ARMY
POWER UNIT PE-205-A
SERIAL NO. [redacted]
ORDER NO. 3112-PHILA-43
HILL DIESEL ENGINE COMPANY
Flexible Coupling - Flywheel Cap Screws

Fig. 97 — Generator to Engine Connection Details

(f). Before removing the main generator, it is necessary to detach the flexible coupling from the flywheel. Do not attempt to take the coupling apart but simply remove the eight 3/8″ capscrews which hold the coupling assembly to the flywheel. These capscrews are removed through the small hand hole opening in the right side of the main generator by turning the engine over so that they can be reached with a wrench. Now the main generator can be moved back off the subbase by hooking the chain fall in the lifting bolt. If there happens to be any shims under the legs of the main generator, lay them aside with care. These shims must be replaced exactly as removed.

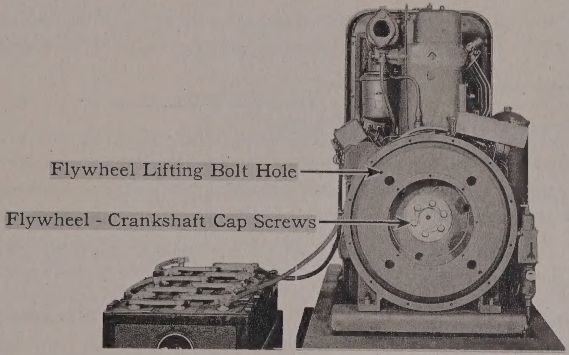


Fig. 98 — Flywheel to Engine Connection Details

(g). Remove the flywheel from the engine. In order to do this you must first take out the lock wires from the six bolts that hold the flywheel to the crankshaft. See Fig. 98. Insert a 1/2″ U.S.S. hex. head capscrew, with a heavy flat washer tight against the head of the capscrew, through a link of the lifting chain well into one of the two bolt holes located near the outside edge of the flywheel. Hook into the lifting chain and lift just enough to hold the flywheel when the six bolts between the flywheel and the crankshaft are removed. Pry the flywheel off the crankshaft by inserting a heavy duty screwdriver in the timing opening of the flywheel housing. Carefully swing the flywheel out of the housing and lower it to the floor.

(h). Remove the starting motor, battery charging generator and voltage regulator from the engine.

(i). Remove the instrument panel from the flywheel housing. In order to do this you must disconnect the lubricating oil pressure line from the gauge. Remove the lubricating oil thermocouple from the base of the oil pan. Remove the water thermocouple from the center of the water manifold. Remove the clip holding the lube oil thermocouple wire to the engine. Remove the clip that holds the starting motor wiring assembly to the flywheel housing. Remove the two 5/16″ capscrews that hold the instrument panel to the flywheel housing. Turn the panel over and remove the two wires at the panel that lead to the safety control also remove at the panel the wire that connects the ammeter to the filterette. Lift the panel off the engine taking care not to break the wires or injure the thermocouples.

(j). Remove the safety control.

(k). Remove all fuel and lubricating oil filters, the fuel transfer pump, radiator, fan, hand crank assembly, and the air cleaner and gland assemblies.

(l). Remove the four bolts that hold the engine to the subbase.

(m). Place a chain sling around the engine so that the engine will balance when it is lifted with a chainfall. Be careful so as not to let the chain damage any tubes or other breakable parts. Lift the engine clear of the subbase. Lay a couple of wood blocks on the floor and lay the engine on its exhaust manifold side so that it will rest on the wood blocks clear of the floor.

(n). Remove the chains, run them through the hand holes and around the oil pan and hook in this position. Lift the engine so it will stand on its head. Lay wood blocks so that the head will be supported clear of the compression release levers on top of the valve covers. Make sure the engine is blocked well so that it will not tip over when the chains are removed.

(o). Remove the oil pan.

(p). Cut the lock wires on the capscrews that hold the flywheel housing to the block. Remove these capscrews and knock the flywheel housing loose with a lead hammer.

(q). Remove the gear case cover.

(r). Remove the lubricating oil pump.

(s). Remove the cotter pins from all main bearing and connecting rod castle nuts. The main bearing caps are numbered from one thru five starting at the front of the engine to prevent a mix-up. Keep all bearing caps in such order that they can be replaced exactly as removed.

(t). The crankshaft can now be lifted out of the block by a couple of men or by using a hoist with a rope around the crankshaft.

(3). Inspection of Parts.— Clean all engine parts with kerosene or a light grade fuel oil. Inspect the bearings for pits or scores and if necessary replace with new bearing halves.

Examine the crankshaft journals for over heating, scoring or excessive wear.

Clean all the drilled oil passages in the cylinder block and crankshaft by flushing out with kerosene or fuel oil and blowing out with air.

(4). Replacing Crankshaft and Rebuilding Engine.— When rebuilding the engine all gaskets damaged in any way must be replaced. Old undamaged gaskets can be used again, however, we strongly recommend that new gaskets be installed throughout.

(a). Things to watch when replacing crankshaft and bearing caps.

1. Clean the inside of the block and bearing surfaces thoroughly. No dirt must be left under the bearing shells.

2. Make sure all bearing caps are replaced exactly as removed and that all bearing cap nuts are pulled down evenly and adjusted with a torque wrench to 110-115 ft. lbs. for the mains and 90-95 ft. lbs. for the connecting rods. Do not back off any nut to make the cotter key slot match the hole in the bolt. Tighten the nut until the next slot matches the hole.

3. Check the end play of the crankshaft (maximum .010″, minimum .005″).

4. When replacing the lubricating oil pump, make sure the capscrews are tight and new lock wire has been inserted.

5. Make sure timing marks on gear train are matched.

(b). Things to watch when replacing gear case cover, flywheel housing and oil pan.

1. Put the flywheel housing on, first doweling it correctly in place. Then insert the capscrews and pull the housing tight to the block. See that the new lock wire has been inserted. Make sure the two joints where the base of the block meets the flywheel housing is sealed with Permatex or gasket cement.

2. Replace the gear case cover using the same technique described above for the flywheel housing — not forgetting to seal the two joints where the base of the block meets the gear case cover.

3. Reinstall the oil pan on the base of the block. Loosely install all the bolts in the top of the oil pan and all the capscrews in the flywheel housing end of the oil pan. Tighten both the capscrews and bolts at the same time so that the oil pan will make a good seal with both the flywheel housing and the base of the block.

(c). Things to watch when putting the engine back on the base.

1. In turning the engine over, place the chains on as before and lay the engine on the exhaust manifold side as before.

2. Take particular care in swinging the engine back in place. Do not damage any parts.

(d). Things to watch when assembling the rest of the engine.

1. Two of the holes for the capscrews which hold the flywheel to the crankshaft are closer together than the rest. Make certain all holes in the flywheel and crankshaft line up before attempting to fasten the flywheel in place. The easiest way to replace the flywheel is to turn one of the capscrew holes in the crankshaft so it is at the highest point i.e. exactly on top. Insert a long stud in this hole and use it as a guide for slinging the flywheel into place. At this point it is a good plan to test the flywheel for wobble. This is accomplished by mounting a dial indicator on the flywheel housing and taking readings from the perpendicular surface of the flywheel. Do not forget to lock the capscrews with new lock wire.

2. Install a new front oil slinger if necessary.

3. When installing the main drive sheave on the front of the crankshaft, make certain the set screw side of the sheave is next to the hand crank side. Line the main drive sheave up with the water pump sheave using a straight edge on the side of the sheaves. It is very important to tighten the set screws well.

4. After replacing the charging generator and V-belts try the belts to see that they are not too tight. Make certain that the generator sheave lines up with the main drive and water pump sheaves.

5. The engine cooling fan is mounted so that it pushes the air through the radiator. Do not mount it backwards. The hollow side of the fan blades should face the radiator.

6. Make certain the thermostat is in the thermostat gland when the gland is mounted on the engine.

7. When wiring the engine, check the wiring diagrams carefully.

8. The main generator should go back into place easily. The flexible coupling must seat correctly in place in the flywheel recess. The capscrews holding the coupling to the flywheel must be tight.

9. The engine must be timed and all operations as indicated under "Adjustment and Operation" followed closely before putting the unit back into service.

n. Engine Governor.—

(1). Governor Service.— Governor faults usually show up in speed variations of the engine, but this does not mean that all such speed variations indicate governor faults.

Therefore, when improper speed variations appear, the following procedure should be carried out:

(a). Check the load to be sure that the speed changes observed are not the result of load fluctuations.

(b). If the load is uniform, carefully check the engine to be sure that all cylinders are firing properly. For example, a sticking injection pump plunger would cause the engine to stop firing in that cylinder and cause the fuel pump governor control rod to bind thus restricting the action of the governor. This is best remedied by putting on a new injection pump.

(c). See that the governor is installed so that no bind exists in any of the parts connecting the governor to the engine.

If neither load nor engine irregularities are found to be the cause of the speed variation, it may be in the governor. If the engine speed changes in regular surges, (a hunt), gradually back off the adjusting screw (B), as described in Section 15 of "Adjustment and Operation," until the surge ceases.

(2). Governor Replacement.— If the surge cannot be eliminated by the above methods the governor probably is at fault and should be replaced as follows:

(a). Remove the pin from the governor arm at (C) and disconnect the governor arm from the governor control rod. See Fig. 99.

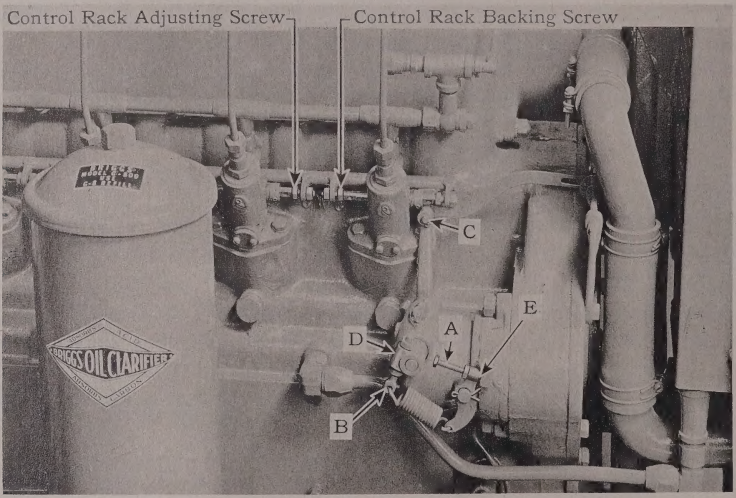


Fig. 99 — Governor and Governor Control Rack Adjustment

(b). Disconnect the ¼" O.D. steel oil tube from the governor.

(c). Remove the two cap screws holding the governor to the block.

(d). Pull the old governor off the engine and return it to the depot.

(e). Place the new governor in place. It will go in only one way as the casting has a pilot.

(f). Replace the capscrews and connect the oil tubing.

(g). Replace the pin at (C) and key in place. Be certain this pin does not bind.

(h). Loosen the binder screw on the governor arm at (D).

(i). Back off screw (A) until there is .020" clearance at (E). Use feeler gauge.

(j). Hold the slack out of the spring at (B) however do not place any tension on the spring. At the same time move the governor arm (C) to the left as far as possible placing the fuel pump governor control rod in wide open position. Hold in this position and tighten screw at (D).

(k). Start the engine and adjust the speed with screw (A.).

(l). Turn screw (B) in to decrease the "No load minus full load" speed drop, and turn it out to increase the "no load minus full load" speed drop and improve the stability of the governing action.

o. Electric Starting and Battery Charging System.—

(1). Starting Switch.— No attempt at adjusting these switches should be made except with accurate meters and equipment. If the starting controls are inoperative refer them to a maintenance station or replace the complete control.

(a). Specifications.—

Volts	24
Solenoid Switch	Part No. SS-4503
Current Draw	1.6 to 1.7 Amps. at 12.0 Volts
Closing Volts	12.5 - 15.5
Opening Volts	1.5 - 2.0
Resistance Unit	12 ohms
Carbon Resistor	80 ohms
Grounded	Yes
Relay	Part No. HRG-4001
Closing Volts*	3.0 - 4.0
Opening Volts‡	0.4 - 1.2
Time Delay‡	0.15 - 0.25 seconds

* Adjust by varying spring tension.

‡ Adjust by varying height of stationary contact.

(b). Inspection.— Inspect the push button and starting switch to see that they are firmly mounted and that the leads are properly connected to the terminals. Check the operation of the units and remove them for a tune-up inspection if the operation is not satisfactory.

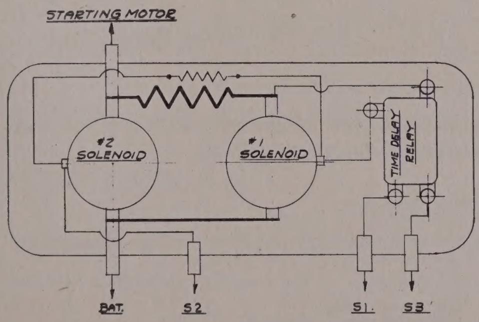


Fig. 100 — Starting Switch Internal Wiring

(c). Tune-up.—

1. Remove the starting motor from the engine.
2. Take out the control box terminal studs and remove the cover nuts. The cover will then lift off.
3. Clean the switch and inspect the leads, insulation and connections for frayed insulation, breaks or improper and loose connections. See Fig. 100.
4. Inspect the push button for loose or corroded connections and terminals.
5. Assemble the terminal studs.
6. Remount the starting motor on the engine and connect the leads.
7. Check the starting operation. If the starter fails to operate or operates too slowly remove the starting motor and controls for a complete overhaul.

8. Connect the voltmeter between the battery terminal of the control box and the starting motor terminal. Operate the starter in the normal manner and read the voltmeter. If the voltage reading is larger than .05 volts per 100 amperes (approximately .25 volts during normal starting) the starting switch should be completely overhauled.

9. Disconnect the leads and remove the terminal studs.

10. Reassemble the cover and studs and reconnect the leads.

(d). Overhaul.—

1. Remove the leads from the push button and tape the battery lead to prevent short circuiting. Remove the mounting nut and press the button out of the panel.

2. Check the push button for grounds and opens. Touch the frame of the button with a test probe and touch each terminal in turn with the other probe. See Fig. 101. If the lamp lights the push button switch is grounded and should be replaced. With button held in, touch the "BAT" and "S1" terminals of the switch. See Fig. 102. The lamp should light. Touch the S2 and S3 terminals with the button in. If the lamp fails to light in either of these tests the switch should be replaced.

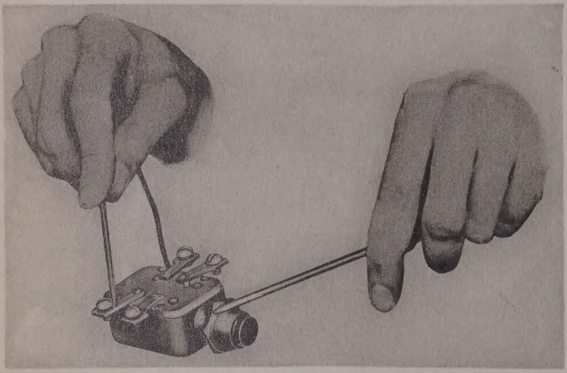


Fig. 101 — Push Button Test

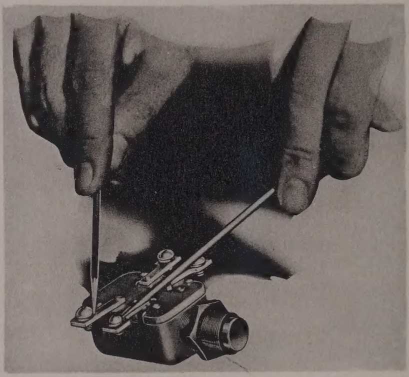


Fig. 102 — Push Button Test

3. Disconnect the leads from the control box and tape the battery lead to prevent short circuiting. Remove the mounting screws and take the starting motor to the bench.

4. Disassembly of Starting Switch Control Box.—

a. Take out the terminal studs with an open end wrench. Remove the washers and rubber grommets from the No. 10-32 terminals.

b. Remove the cover holding nuts. Lift cover off.

c. Remove the lockwashers from the ⅜-16 solenoid terminals.

d. Take off the nut that holds the terminal connector. See Fig. 103, Page 105. Remove the two leads from the relay and the one lead to the solenoid and lift off the connector.

e. Remove the screws holding the carbon resistor. Lift off the lead, resistor and washers.

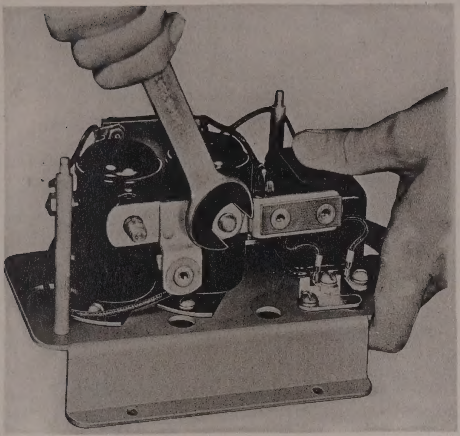


Fig. 103 — Disassembly of Starting Switch

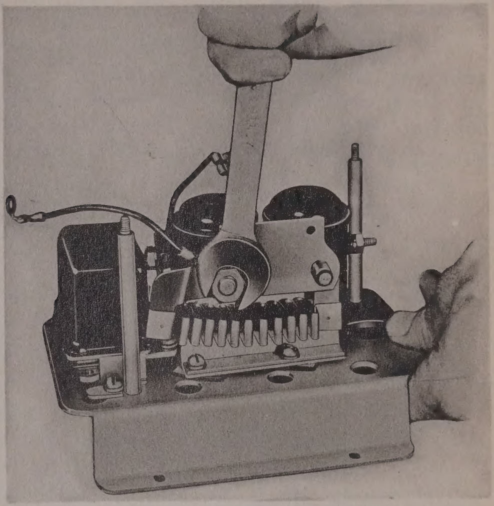


Fig. 104 — Disassembly of Starting Switch

f. Remove the nut holding the resistor insulation to the solenoid terminals. See Fig. 104. Take off the lockwasher, lead, insulation and resistance.

g. Remove the leads from the relay terminals.

h. Remove the two solenoid mounting screws that hold the resistor insulation and retainer. Lift off the retainer and insulation.

i. Remove the solenoid and relay mounting screws and lift the units from the base.

j. Remove the leads from the solenoid terminal.

5. Inspection.—

a. Inspect the leads for breaks and improperly soldered or corroded terminals and replace or repair any that are found to be defective.

b. Inspect the carbon resistor for cracks and check its resistance on an ohmmeter. Replace the resistor if it is cracked or if its resistance in not within 76 to 84 ohms.

c. Inspect the metal resistance unit and replace it if it is corroded excessively. Clean the unit thoroughly.

d. Inspect the insulation and washers. Replace any that are cracked or oil soaked.

e. Inspect the terminals and studs for stripped threads and corrosion and replace any that cannot be cleaned up to give satisfactory service.

f. Inspect the terminal connector for loose terminals, cracked insulation, corroded connectors and for defective leads and replace the assembly if any of these conditions are found.

6. Solenoid Switch Tests.— Connect a variable resistance in series with the No. 10-32 terminal of a solenoid switch, the switch base and a 24-volt battery. Connect a voltmeter from the switch terminal to the base. Increase the voltage slowly noting the voltmeter reading when the switch closes as indicated by a click. Reduce voltage slowly and note the opening voltage.

Replace the switch if it does not close at 12.5 to 15.5 volts and open at 1.5 to 2.0 volts.

Connect a 12-volt battery, carbon pile and a 200-ampere ammeter in series with the two ⅜-16 terminals of a solenoid. Connect a voltmeter across the two ⅜-16 terminals of the solenoid. Connect the solenoid base to one battery terminal and connect the No. 10-32 terminal to the other battery terminal. Adjust the current to 100 amperes and read the voltmeter. If the voltmeter shows a reading larger than .05 volts replace the solenoid switch.

Repeat the above tests on the second solenoid switch.

7. Relay Tests.—

a. Remove the relay cover and inspect the contacts. If the contacts are burned file lengthwise and parallel to the armature with a very fine contact file. Clean the contacts with a strip of linen tape wet with carbon tetrachloride and remove any residue with a clean dry piece of tape.

b. Inspect the insulation and windings for evidences of breakage or cracks and replace the relay if necessary.

c. Check the armature air gap with a .034" - .038" flat gauge. Adjust the gap by bending the bracket holding the upper auxiliary contact.

d. Connect a 6-volt battery, variable resistance, voltmeter and two 6-volt lamps as illustrated in Fig. 105. Insert all the resistance in the circuit. Lamp No. 1 should be lit. Slowly reduce the resistance noting the voltage just as lamp No. 1 goes out. This voltage should be between 3.0 and 4.0 volts and is adjusted by bending the lower armature spring hanger. Increasing the spring tension increases the voltage at which the contacts close. Decrease the voltage slowly and note the voltage at which Lamp No. 1 goes on. This voltage should be 0.4 to 1.2 volts and is adjusted by varying the height of the main stationary contact. Keep the contacts aligned when adjusting.

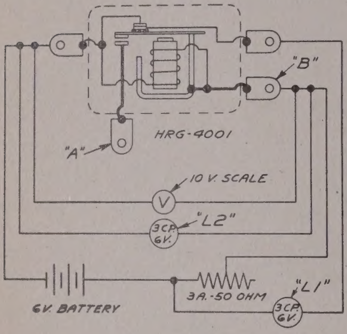


Fig. 105 — Relay Test

If the relay cannot be adjusted as above replace the relay.

With test probes touch the base of the relay with one probe and each terminal in turn with the other probe. If the lamp lights it indicates a grounded relay which should be replaced. Touch the two terminals marked "A" and "B" on Fig. 105 and hold the armature down. If the lamp fails to light it indicates an open circuit and the relay should be replaced.

Replace the relay cover and clinch the ears to hold it in place.

8. Reassembly the control box by reversing the disassembly process and remount the starting motor on the engine.

(2). Starting Motor.— Lubricate the motor every 100 hours of operation by adding 3 to 5 drops of medium engine oil to the oiler at the top of the commutator end head.

After the starting motor has been in storage for an extended period it should be removed, dismantled and cleaned. Clean the bendix drive thoroughly and lubricate the shaft sparingly with light oil. Lubricate the bearings with medium engine oil. Inspect the wiring for loose or corroded connections and for broken leads. Make sure the insulation on the wiring has not become frayed.

(a). Removing Starting Motor From Engine.—

1. Disconnect the wiring harness from the control box mounted on the top of the starting motor. Extreme care should be taken to mark the wires and posts so they can be reconnected correctly.

2. Remove the three ⅜″ capscrews that hold the starting motor to the flywheel housing. Support the starting motor carefully during this operation and then lift the motor off the engine.

(b). Trouble Shooting.—

1. Starter Does not Operate.—

Due to:	**Corrections:**
Shorted or open wiring	Inspect wiring
Defective push button	Replace
Defective Relay	Replace
Defective solenoid switch	Replace
Defective motor	Remove for an overhaul
Poor brush contact	Clean commutator and inspect brushes

2. Starter Spins But Does Not Crank Engine.—

Broken or Defective bendix	Remove motor and clean and repair bendix

3. Starter Turns Too Slow.—

Too heavy engine oil	Check oil for correct viscosity at the operating temperature
High resistance wiring	Inspect wiring and connections
High resistance ground connections	Inspect ground at battery and motor
Solenoid switch inoperative	Replace switch
Relay inoperative	Replace relay
Worn brushes	Inspect and replace brushes
Dirty commutator	Clean commutator
Defective starting motor	Remove motor for an overhaul

(c). 100 Hour Lubrication and General Inspection.—

Tools.—

¼″ Screwdriver
Medium Engine Oil — S.A.E. No. 20
00 or 000 Sandpaper

1. Commutator and Brushes.— Remove the head band and inspect the commutator. If the commutator is dirty or discolored, it can be cleaned by holding a piece of 00 or 000 sandpaper against it while turning the armature slowly. Blow the sand out of the motor after cleaning the commutator. If the commutator is rough or worn the motor should be removed from the engine for an overhaul.

Inspect the brushes. The brushes should slide freely in their holders and make full contact on the commutator. Make Sure the brushes are perfectly in line with the commutator segments. If the brush holders need repair or if the brushes are worn to less than ½ their original length the motor should be removed for an overhaul.

2. Wiring.— Inspect the wiring from the battery to ground, from the battery to the starting switch and from the switch to the motor for loose or corroded connections and for frayed insulation.

3. Lubrication.— Add 3 to 5 drops of medium engine oil to the oiler in the commutator end head.

4. Starting Controls.— Inspect the push botton and starting switch to see that they are firmly mounted and that the leads are properly connected to the terminals. Check the operation of the units and remove them for a tune-up inspection if the operation is not satisfactory.

(d). 1000-Hour Tune-up.—

Tools.—

¼″ Screwdriver
Medium Engine Oil — S.A.E. No. 20
Light Engine Oil — S.A.E. No. 10
00 or 000 Sandpaper
Test Voltmeter
Test Ammeter
Battery (24 volt)
Torque Arm and Spring Scale (50-pound capacity)
Carbon Pile Rheostat
⅜″ Screwdriver
Wrenches for removing units from engine
Spring Scale (5-pound capacity)
Dial Indicator

1. Remove the motor from the engine and take off the head band.

2. Inspect the commutator, brushes and wiring and lubricate the motor as described in the 100-hour general inspection.

3. Remove the screws holding the pinion housing to the frame and slide the housing off of the motor. Loosen the Bendix shaft spring screw and slide the Bendix off the shaft. See Fig. 106.

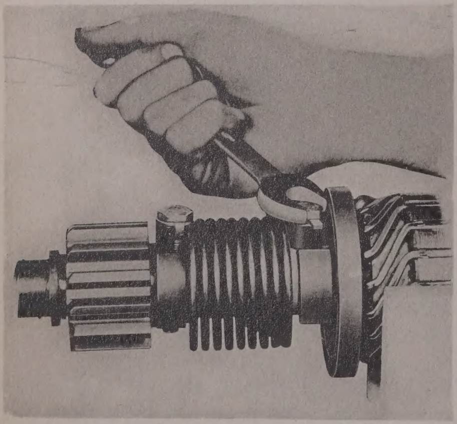


Fig. 106 — Removing Starting Motor Bendix

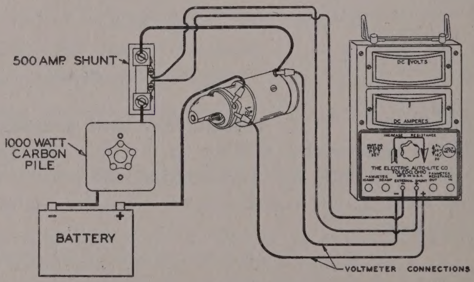

500 AMP. SHUNT
1000 WATT CARBON PILE
BATTERY
DC VOLTS
DC AMPERES
INCREASE RESISTANCE
THE ELECTRIC AUTO-LITE CO
TOLEDO, OHIO
MFD. IN U.S.A.
EXTERNAL SHUNT
VOLTMETER CONNECTIONS

Fig.107 — Starting Motor Test

Clean the Bendix and armature shaft in kerosene and lubricate sparingly with light oil. Inspect the Bendix for worn parts or a distorted spring and replace any faulty parts.

4. Assemble the Bendix on the armature shaft making sure the two Woodruff keys are in place. Tighten the shaft spring screw so that it enters the hole in the armature shaft.

5. Clean the pinion housing and soak the bearing in medium engine oil. Assemble the housing on the motor and fasten with the holding screws.

6. Remove the terminal studs and cover nuts from the control box and lift off the cover so that the motor terminal is accessible. Connect an ammeter, carbon pile rheostat and battery in series with the motor terminal and the frame. Connect a voltmeter from the motor terminal to the motor frame. These connections are shown in Fig. 107, Page 108. Adjust the voltage to 20.0 volts and read the ammeter which should not show more than 65 amperes. If a tachometer is available, hold it against the drive end of the armature shaft and read the speed while operating at 20.0 volts. The starting motor speed should be at least 5300 R.P.M. If the current is high and the speed low inspect the bearings for correct alignment and make sure the armature turns freely without interference. If the current is low, inspect the brushes for correct seating on the commutator and inspect the internal connections of the motor for high resistance.

7. With the motor connected as above and using a spring scale and torque arm, measure the stall torque. Adjust the voltage to 4.0 volts and read the ammeter and spring scale. The current should be 380 amperes maximum and the torque should be more than 21 pounds feet. If the current is high or the torque too low, inspect the motor for high resistance connections, incorrect bearing alignment and incorrect brush seating.

8. Clean the switch and inspect the leads, insulation and connections for frayed insulation, breaks or improper and loose connections.

9. Inspect the push button for loose or corroded connections and terminals.

10. Replace the control box cover and assemble the terminal studs.

11. Reassemble the motor on the engine.

12. Check the starting operation. If the starter fails to operate or operates too slowly remove the starting motor and controls for a complete overhaul.

(e). 2000-Hour Overhaul.—

Tools.—

¼″ Screwdriver
⅜″ Screwdriver
Pole Piece Screwdriver
00 or 000 Sandpaper
Voltmeter
Ammeter
Battery
Carbon Pile Rheostat
Wrenches
Growler
Test Probes
Dial Indicator

1. Remove the leads from the push button and tape the battery lead to prevent short circuiting. Remove the mounting nut and press the button out of the panel.

2. Check the push button for grounds and opens. Touch the frame of the button with a test probe and touch each terminal in turn with the other probe as shown in Fig. 101, Page 104. If the lamp lights the push button switch is grounded and should be replaced. Touch the "BAT" and "S1" terminals of the switch and hold the button in. The lamp should light. Touch the S2 and S3 terminals with the button in as in Fig. 102, Page 104. If the lamp fails to light in either of these tests the switch should be replaced.

3. Disconnect the leads from the control box and tape the battery lead to prevent short circuiting. Take out the motor flange bolts and the motor can be taken to the bench for an overhaul.

4. Disassembly.—

a. Remove the control box terminal studs and cover nuts. Lift off the cover.

b. Remove the connector from the starting motor terminal post.

c. Remove the control box mounting screws and take the box off of the motor.

d. Remove the motor head band.

e. Lift the brushes out of the holders. See Fig. 108.

f. Remove the commutator end head holding screws. Take the head off of the motor.

g. Remove the pinion housing holding screws. Take the pinion housing and armature off of the frame and field.

h. Press the armature out of the pinion housing as in Fig. 109.

i. Back off the Bendix shaft spring screw and slide the Bendix assembly off of the shaft. See Fig. 106, Page 108.

j. Remove the intermediate plate and thrust washers from the armature shaft.

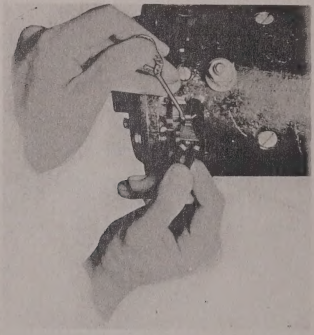


Fig. 108 — Lifting Out Starting Motor Brushes

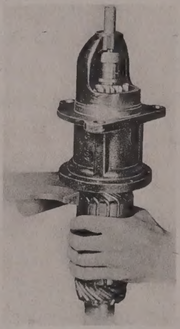


Fig. 109 — Pressing Out Starting Motor Armature

5. Inspection.—

a. Armature.— Inspect the armature and commutator for evidences of wear. Inspect the insulation and soldering to make sure all coils are in proper working order. Make sure the coils are properly staked to commutator and core slots. If the shaft or core is worn the armature should be replaced. Other visible faults should be repaired or the armature replaced. If it is necessary to turn the commutator take only a light cut with the armature mounted on the bearing seats and not on the shaft centers. Remove all burrs from the commutator and undercut the mica segments clean and squarely to a depth of 1/32 inch.

Check the armature for grounds with test probes. Touch one probe to the shaft and touch each commutator segment in turn with the other probe as shown in Fig. 110. If a ground is present the lamp will light. Do not touch the probes to the bearing or brush surface as an arc would burn the smooth finish. Check the armature for shortcircuits on a growler. Place the armature on the growler and hold a steel strip on the core as illustrated in Fig. 111. Rotate the armature slowly and if a ground is present the steel strip will vibrate. Replace the armature if it is grounded or shorted.

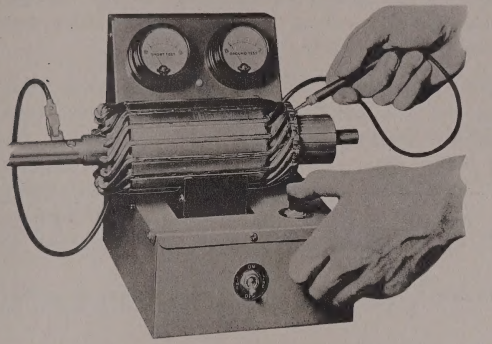


Fig. 110 — Starting Motor Armature Ground Test

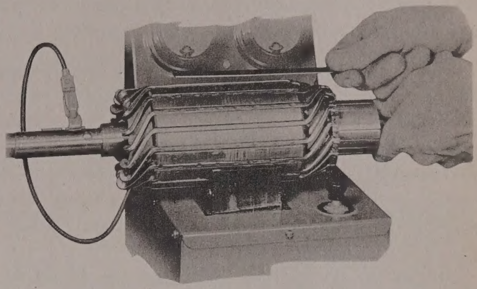


Fig. 111 — Starting Motor Armature Ground Test

b. Frame and Field.— Inspect the brushes. If they are oil-soaked or are worn to less than ⅜ inches long they should be replaced. Make sure the grounded brush terminals are securely fastened and are free from corrosion. To replace the insulated brushes unsolder the lead from the brush connector and pry open the loop in the connector. Insert the new brush lead to its full depth in the loop and clinch tightly before resoldering. A good soldering job must be done to prevent lost of starting motor efficiency due to a poor contact.

Check the field coils and terminal post for grounds and open circuits. Make sure the brushes are not touching the frame or connectors and touch one probe to the terminal post and the other probe to the frame. See Fig. 112. If a ground is present the lamp will light. Touch one probe to the terminal post and the other probe to one of the insulated brushes as illustrated in Fig. 113. If an open circuit is present the lamp will not light.

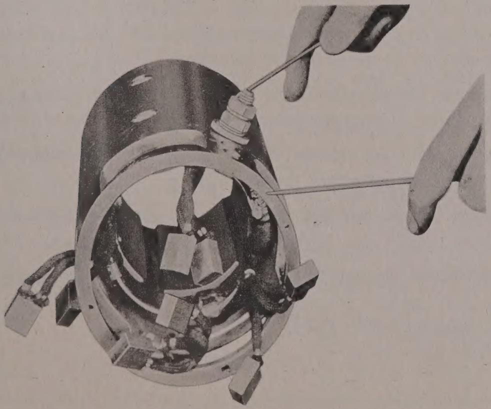


Fig. 112 — Starting Motor
Field Coil Ground Test

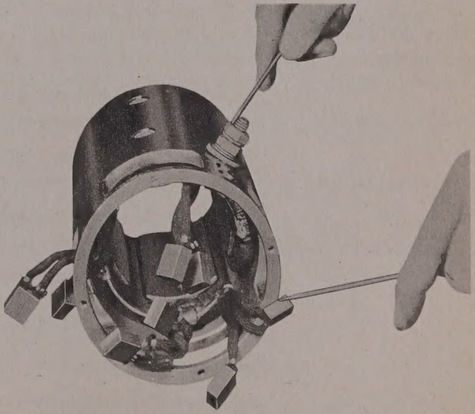


Fig. 113 — Starting Motor
Field Open Circuit Test

If a ground or open is present disassemble the frame and field and inspect each part. Remove the terminal post by taking off the nut and washers and pressing the post out of the frame. Inspect the washers and insulating bushing and replace those that are not in good condition. Take out the pole piece screws and remove the pole pieces and field coils. Inspect the field coils for faulty insulation and check for opens with the test probes. If it is necessary to replace any field coil make sure the connectors are clinched tightly and soldered properly. Reassemble the field coils in the frame using pole piece screws that have been dipped in boiled linseed oil. As the screws are tightened hit the frame a few sharp blows with a rawhide hammer to properly align the pole pieces. Assemble the terminal post and washers and again check the assembly for grounds and opens with the test probes.

c. Commutator End Head.— Disassemble the brush holder plate from the head. Remove the oiler and felt wick from the head and take out the shaft cover and felt pad. Clean both plates thoroughly and inspect them for cracks. Inspect the brush holders for distortion. Inspect the bearing and if it is worn excessively replace it. Use the proper arbor to install the new bearing in order to secure the proper bearing fit. Replace the head if it is damaged and replace the brush holder plate if the brush holders or springs are corroded, distorted or bent. Soak the bearing and felts in medium engine oil and reassemble the end head. Make sure the drain hole in the end cap is at the bottom of the end head.

With test probes check the brush holders for grounds and replace the brush holder plate if a ground is present.

d. Pinion Housing.— Clean the housing and inspect it for cracks. Inspect the bearing for wear and replace it if it is worn excessively. Use the correct arbor to install a new bearing to secure the right bearing fit. Soak the bearing in medium engine oil.

e. Bendix Drive.— Disassemble and clean the Bendix drive. Inspect each part for wear and distortion. Replace any faulty part and lubricate the threads sparingly with light oil. Use new lock washers every time the Bendix is assembled.

f. Intermediate Bearing.— Clean the intermediate bearing and plate and inspect for cracks and wear. Replace the plate or bearing if necessary using the correct arbor to install the bearing. Soak the bearing in medium engine oil.

6. Assembly.—

a. Assemble the two 1" steel thrust washers on the drive end of the armature shaft and assemble the intermediate bearing on the shaft.

b. Apply a thin coat of light oil to the armature shaft and assemble the Bendix drive on the shaft. Make sure the two Woodruff keys are in their proper place and tighten the Bendix spring screws. Bend the ears of the lock washers to prevent the screws from loosening.

c. Assemble the armature in the pinion housing and turn the intermediate plate so that the dowel pin fits into the slot. Press the intermediate plate down against the shoulder in the housing.

d. Assemble the armature and pinion housing on the frame and field and fasten with the holding screws. Tighten the screws securely with lock washers on all screws.

e. Assemble the fibre thrust washer, for controlling end play, on the commutator end of the shaft and then assemble the 5/8" steel washer.

f. Assemble the commutator end head on the motor and fasten with the holding screws.

g. Assemble the brushes in their holders.

7. Final Inspection.—

a. Inspect the alignment of the brushes on the commutator. If the brushes are not perfectly in line with the commutator segments remove the head and replace the brush holder plate.

b. With a spring scale measure the brush spring tension. Hook the scale under the brush spring at the bend and pull on a line parallel to the face of the brush. Take the reading just as the spring leaves the brush. If the tension is not between 40 and 50 ounces remove the head and twist the spring holder with pliers. Always remove the brushes from the holders before removing the end head.

c. Check the armature end play. Mount a dial indicator on the pinion housing with its shaft against the end of the armature. If the end play is not within .005″ to .030″ remove the commutator end head and change the fibre thrust washer to one of the following:

Part No.	**Size**
MU-54	1/32″ thick
MU-54A	1/64″ thick
MU-54B	3/64″ thick

Armature end play can also be measured by measuring the clearance, with the armature in its extreme positions, between the Bendix drive stop and the pinion housing. See Fig. 114.

d. Add 5 to 10 drops of medium engine oil to the oiler in the commutator end head.

e. Check the no load current draw and lock torque as outlined in the 1000-hour tune-up inspection.

(3). Battery Charging Generator.— The generator does not require periodic lubrication. If the generator has been in storage for an extended period it should be disassembled and cleaned and fresh lubrication applied to the bearings and felts before putting into service. Keep the connections clean and tight and inspect the wiring for breaks.

(a) Removing Battery Charging Generator From Engine.—

1. Remove the wires connecting the voltage regulator to the charging generator at the voltage regulator end. Do this by removing the two wing nuts on the connection box of the voltage regulator and unhooking the wires inside. Loosen the two knurled flexible tubing nuts on the top of the voltage regulator connection box and pull the wires out of the box. These wires should be marked or tagged so they can be replaced on the proper terminals, otherwise the voltage regulator may be damaged.

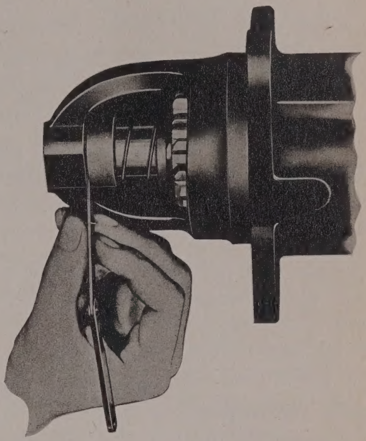


Fig. 114 — Measuring Starting Motor Armature End Play

2. Remove the V-belt tightener strap from the charging generator and the cylinder block.

3. Loosen the charging generator end bracket from the engine by removing the two capscrews holding it thru the hand hole door to the cylinder block.

4. Loosen the lock nuts on the long bolt (beneath the charging generator) that holds the generator to the main support bracket. Remove this bolt and charging generator can be lifted off the engine. Handle the charging generator carefully, it must not be dropped or damaged in any way.

(b). Trouble Shooting.—

1. Battery Runs Down.—

Due to:	**Corrections:**
High resistance wiring	Inspect the wiring and connections
Regulator inoperative	Repair or replace regulator

High resistance ground circuit	Inspect ground connections at battery and generator
Shorted wiring	Inspect wiring
Worn brushes	Inspect and replace brushes
Dirty commutator	Clean commutator
Generator output too low	Readjust regulator

2. Battery Becomes Overcharged.—

Regulator set too high	Readjust regulator
Regulator inoperative	Readjust or replace regulator

(c). 100-Hour Lubrication and General Inspection.—

Tools.—

¼" Screwdriver
Medium Engine Oil — S.A.E. No. 20
00 or 000 Sandpaper

1. Commutator and Brushes.— Remove the head band and inspect the commutator. If the commutator is dirty or discolored it can be cleaned by holding a piece of 00 or 000 sandpaper against it while turning the armature slowly. Blow the sand out of the generator after cleaning the commutator. If the commutator is rough or worn the generator should be removed and completely overhauled.

Inspect the brushes and brush holders. The brushes should slide freely in their holders and should be perfectly in line with the commutator segments. If the brushes do not slide freely, are out of alignment, oil soaked or worn to less than one-half of their original length the generator should be removed for a tune-up inspection.

2. Wiring.— Visual inspection. Inspect all wiring from the generator to the regulator, from the regulator to the battery and from the battery to ground for worn or frayed insulation, broken wires and for loose or corroded connections. Repair or replace defective wiring.

3. Operation.— Run the generator at near maximum output and note the commutator action. If there is excessive arcing between the brushes and commutator remove the generator for a tune-up inspection. Replace the head band.

Test the regulator as outlined in the regulator section.

(d). 1000-Hour Tune-up.—

Tools.—

¼" Screwdriver
Medium Engine Oil — S.A.E. No. 20
00 or 000 Sandpaper
Test Voltmeter
Test Ammeter
Battery (24 volt)
Potentiometer or slide wire rheostat
⅜" Screwdriver
Wrenches for removing units from engine
Spring scale (5-lb. capacity)
Dial indicator

1. Remove the generator from the engine and take off the head band.

2. Inspect the commutator. If the commutator is dirty or discolored, it can be cleaned by holding a piece of 00 or 000 sandpaper against it while turning the armature slowly. Blow the sand out of the generator after cleaning the commutator. If the commutator is rough or worn the generator should be disassembled and completely overhauled.

3. Inspect the Brushes. Each brush should slide freely and should be free from oil and dirt. Brushes that are oil soaked or are worn to less than one-half of their original length should be replaced.

To remove the brushes lift the brush arm and disconnect the brush lead. Make sure the brushes are assembled so that the beveled face of the brush fits the commutator. Check the alignment to make sure that the brush edge is parallel with the commutator segments. If the alignment is off or if the brushes do not slide freely the commutator end plate should be disassembled and inspected as described in the overhaul procedure.

After the new brushes are installed they should be sanded to make sure of the proper fit on the commutator. To sand brushes cut a strip of 00 or 000 sandpaper the exact width of the commutator. Slip this strip under a brush and pull so that the brush is forced against the brush holder. Be careful not to break the edge of the brush and repeat the sanding of the other brushes.

Measure the brush spring tension. Hook a spring scale under the brush arm near the brush and pull on a line parallel to the face of the brush. Take the reading just as the arm leaves the brush. The tension should be 23 to 26 ounces with new brushes. See Fig. 115.

If the tension is too great, the brushes and commutator will wear excessively while if the tension is too little there will be a tendency to arc at the commutator. To change the spring tension disassemble the end head and bend the spring.

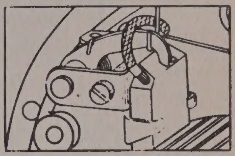


Fig. 115 — Generator Brush Tension

New brushes should be run in to make sure of a perfect brush fit before output test or adjustments are made on the generator. To run in new brushes the generator should be run under load long enough to secure a perfect brush fit.

4. Check armature end play. Armature end play should be measured with a dial indicator. The end play should be held between .003" and .010". If the end play is too great it can be reduced by installing thrust washers on the armature shaft just inside either end head. Make sure when installing thrust washers that the brushes are correctly centered in the commutator.

5. Bench test the generator without the regulator in the circuit. Connect an ammeter, battery and variable resistance in series with the field terminal and the generator frame. Connect a voltmeter from the field terminal to the generator frame. Adjust the variable resistance so that the voltmeter reads 24.2 volts and read the ammeter. If the current is not between .79 and .88 amperes it indicates faulty field coils or connections.

Connect an ammeter, battery and variable resistance in series with the armature terminal and the generator frame. Connect the field terminal to the armature terminal with a jumper. Connect a voltmeter from the armature terminal to the generator frame. Adjust the voltage to 24.2 volts by varying the resistance. The generator armature should turn slowly and the ammeter should show a reading of 2.47 to 2.72 amperes. If the current is not within these limits it indicates high resistance connections, worn bearings or poor brush contact.

Mount the generator on a test bench or if none is available on the engine. Connect the field terminal to the armature terminal with a jumper lead. Connect an ammeter in series with the armature terminal, a battery and the generator frame. Start the engine and increase the speed slowly noting the ammeter reading. An output of 10 amperes should be obtainable. Do not increase the output above this figure as a greater output may burn the generator fields and armature.

6. Remount the generator on the engine and connect the leads to their respective terminals.

7. Inspect the wiring and operation of the generator as described in the 100-hour general inspection.

(e). 2000-Hour Overhaul.—

Tools.—

¼″ Screwdriver
Pole Piece Screwdriver
00 or 000 Sandpaper
Voltmeter
Ammeter
Battery (24 volt)
Wrenches
Arbor press
Growler
Test probes
Dial Indicator

1. Disconnect the leads from the generator.

2. Remove the mounting bolts and take the generator off of the engine.

3. Disassembly.—

a. Remove the nut and lock washer from the armature shaft.

b. Remove the generator head band.

c. Disconnect the leads from the brush holders and lift the brushes out of the holders.

d. Remove the commutator end cover screws and take off the cover and gasket.

e. Remove the screws from the armature shaft and lift out the washers and retainers.

f. Remove the commutator end head holding screws. Pull the commutator end head from the generator.

g. Remove the drive end head holding screws and lift the armature and drive end head from the frame and field.

h. Remove pulley from armature shaft either by tapping as shown in Fig. 116 or by using a puller.

i. Press the armature out of the drive end head with an arbor press as shown in Fig. 117.

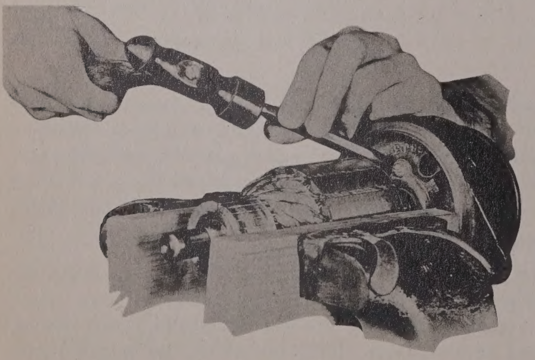


Fig. 116 — Removing Generator Armature Pulley

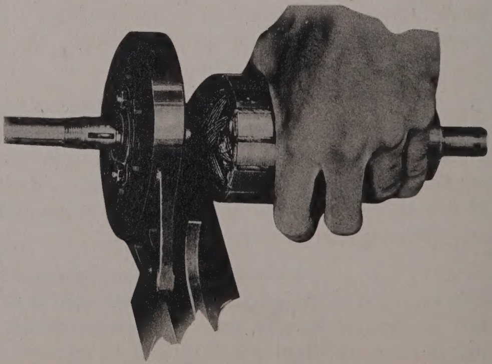


Fig. 117 — Pressing Out Generator Armature

4. Inspection.—

a. Armature.— Inspect the armature and commutator for evidences of wear. Inspect the insulation and soldering to make sure all coils are in proper working order. Check the armature for grounds with test probes consisting of a lamp in series with two points and connected to a source of electricity. Touch one probe to the armature shaft (not on bearing surfaces) and touch the other probe to each commutator segment. See Fig. 118. Do not touch the brush surface of the commutator as an arc would mar the smooth finish. If an armature coil or commutator segment is grounded the lamp will light. If the ground is accessible it should be repaired, otherwise replace the grounded armature.

Check the armature for shorts with a milliammeter and replace the armature if it is found to be shorted. Check for open windings by touching one test probe to a commutator segment and the other to a segment approximately opposite. If the lamp does not light the coil is open and the armature should be replaced.

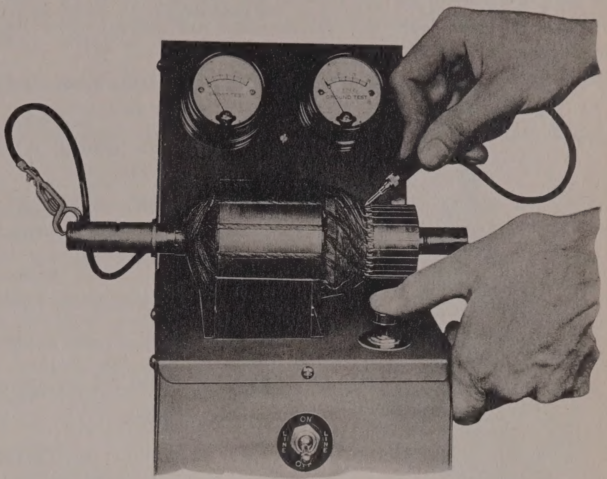


Fig. 118 — Generator Armature Ground Test

If the bearing seats are worn excessively replace the armature. If the commutator is rough or worn it should be turned down in a lathe. Mount the armature on the bearing seats and not on the shaft centers. Take only a light cut and remove all burrs. Undercut the mica to a depth of 1/32 inch after turning the commutator. The undercut should be square and free from burrs.

b. Frame and Field.— Inspect the insulation on the field coils and leads and replace any faulty part. Inspect the leads and terminal posts for broken wires, frayed insulations or poorly soldered terminals.

With test probes check the field coils for grounds and opens. Touch the probe to the field terminal and touch the other to an unpainted ground on the frame. If the field coils or post are grounded the lamp will light. Touch one probe to the field lead and the other to the field terminal post. If the coils or leads are open the lamp will not light.

If it is necessary to replace a field coil remove the pole piece screws. Assemble the new coils on the pole pieces and tighten securely with pole piece screws that have been dipped in boiled linseed oil. As the screws are tightened the frame should be struck with a rawhide hammer a few times to properly settle and align the pole pieces.

c. Commutator End Head.— Disassemble the brush holder plate from the end head. Clean both plates thoroughly and inspect for evidences of failure. Do not clean the bearing and felt washers in gasoline or other grease solvent. Wipe them with a clean rag and relubricate the bearing with a high melting point grease. Soak the felt washers in medium engine oil.

Inspect the brush arms and holders to see that they are not bent or corroded. Inspect the bearing for evidences of wear.

Reassemble the end head and with test probes check the brush holders for grounds. Replace the brush holder plate if the insulated brush holder is grounded.

d. Drive End Head.— Disassemble the end head and wipe the grease from the felt washers and bearing. Clean the head and retainers thoroughly and inspect them for wear or failure. Wipe the grease from the bearing and inspect for wear, then repack it with a high melting point grease. Wipe the grease from the felt washers and inspect them for rips and tears. Soak the felts in oil then reassemble the drive end head.

5. Reassembly.—

a. Press the armature shaft into the drive end head making sure the bearing is pressed tightly against the shoulder on the shaft. See Fig. 119.

b. Assemble the drive end head and armature on the frame and field and install the holding screws. Do not tighten the screws.

c. Assemble the commutator end head on the generator and fasten with the holding screws.

d. Assemble the shaft spacer, spring washer, felt washer retainer, felt washer, felt washer retainer, ball bearing, bearing retainer washer and bearing retaining screw on the commutator end of the armature shaft.

e. Tighten the drive end head holding screws, the commutator end head holding screws and the bearing retaining screws. All of these screws must have lock washers.

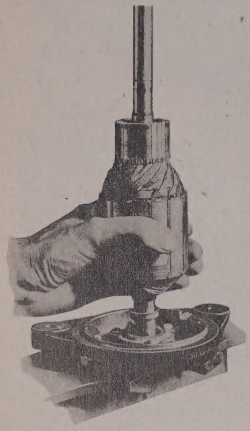


Fig. 119 — Pressing in Generator Armature Shaft

f. Check the armature end play with a dial indicator. The end play should be .003″ to .010″. If it is too great, the end play can be reduced by installing thrust washers just inside of either end head. Keep the brushes centered on the commutator when installing thrust washers.

g. Assemble the commutator end cover and gasket.

h. Assemble the drive pulley and shaft nut making sure the Woodruff key is in place.

i. Assemble the brushes in their holders and connect the leads. The lead from the field coil should be connected at the grounded brush while the lead from the terminal post should be connected to the insulated brush holder.

j. Assemble the head band.

6. Testing and Adjusting.— Complete the 1000-hour tune-up.

(4). Current-Voltage Regulator.— Do not attempt to adjust the regulator without the proper tools and meter. The regulator is adjusted and sealed at the factory and should need no adjustments when it is installed. However, if the regulator needs repairs or adjustments it should be referred to a maintenance station which is equipped to perform the operations described in the 1000-hour tune-up.

(a). Removing Current-Voltage Regulator From Engine.—

1. Remove the three wires connecting the voltage regulator to the battery charging generator and filterette at the voltage regulator end. Do this by removing the two wing nuts on the connection box of the voltage regulator and unhooking the wires inside. Loosen the three knurled nuts on the top of the voltage regulator connection box and pull the wires out of the box. These wires should be marked or tagged so they can be replaced on the proper terminals, otherwise the voltage regulator may be damaged.

2. Take the voltage regulator off the engine by removing the three ⅜″ bolts that hold its mounting plate to the base of the engine.

(b). Trouble Shooting.— The following symptoms and their checks are designed to quickly locate the caused of regulator trouble.

1. Low Charging Rate with a Fully Charged Battery.— A fully charged battery and a low charging rate indicates normal regulator operation.

A further check of the regulator operation can be made by using the starting motor for 5 to 10 seconds. Then start the engine and operate at a generator speed of 2500 to 3000 R.P.M. The charging rate should rise to its maximum value then taper off to a minimum charge as the battery becomes charged.

2. High Charging Rate With a Fully Charged Battery.— This is usually an indication that the voltage regulator is not operating correctly. The high voltage will cause the battery to gas excessively and in general will have a detrimental effect on all connected load.

Connect an ammeter in series with the regulator (b) terminal and the lead removed from the terminal. Run the generator at a medium speed and perform the following operations. After each test is completed reconnect whatever leaks have been opened.

a. Operation.— Disconnect the field lead at the generator.

Effect.—

1. Output drops to zero.
2. Output does not drop.

Cause and Remedy.—

1. Shorted field circuit in regulator or in wiring harness. See test b.
2. Shorted field circuit in generator. Inspect generator.

b. Operation.— Disconnect the field lead at the regulator.

Effect.—

1. Output drops to zero.
2. Output does not drop.

Cause and Remedy.—

1. Shorted field in regulator. See test (c).
2. Shorted wiring harness. Repair or replace harness.

c. Operation.— Remove the regulator cover and hold the voltage regulator contacts open.

Effect.—

1. Output drops to zero.
2. Output does not drop.

Cause and Remedy.—

1. Regulator contacts sticking, regulator out of adjustment or regulator inoperative. Clean contacts, test (f); check operation, test (e); high resistance, test (d).

2. Shorted field circuit in the regulator. Clean the regulator contacts and inspect the regulator visually for incorrect wiring between units and shorted leads.

d. Operation.— Operate the units at 5 amperes output and measure the voltage drop from the regulator base to the generator frame.

Effect.—

1. Voltage reading below .02 volts.
2. Voltage reading above .02 volts.

Cause and Remedy.—

1. Ground circuit O.K. See test (e).
2. Inspect ground lead for breaks and poor connections and eliminate the high resistance. See test (e).

e. Operation.— Connect a headphone from the regulator field terminal to the base and hold the current regulator contacts closed.

Effect.—

1. A steady beat is heard.
2. An unsteady beat is heard.
3. No beat is heard.

Cause and Remedy.—

1. Voltage regulator operating. Reset regulator as in the operation test in the 1000-hour tune-up instructions.

2. Dirty or sticking contacts. Clean contacts as in test (f).

3. Inoperative voltage regulator unit. Remove regulator for an overhaul.

f. Clean the voltage regulator contacts with a No. 6 American Swiss cut equalling file. File lengthwise and parallel to the length of the armature and then clean the contacts with clean linen tape. First draw a piece of tape that has been wet with carbon tetrachloride between the contacts then follow with dry tape. Reset the regulator operation as in the operation test in the 1000 hour tune-up instructions.

3. Low Battery and a Low or No Charging Rate.— Check all wiring and loose connections, frayed insulation and high resistance connections and correct any fault.

Make sure the generator operates correctly without the regulator in the circuit. Remove the (A) and (B) leads from the regulator and connect an ammeter between them. Remove the field lead from the regulator and while operating at idle speed touch the field lead to the armature lead. Increase the speed slowly noting the charging rate. Do not increase the output above the rated output of the generator. If the generator output will not build up inspect the wiring harness for short and open circuits and remove the generator for an overhaul.

Connect an ammeter between the battery lead and the regulator (B) terminal. Connect the field lead to the regulator (F) terminal and connect the armature lead to the regulator (A) terminal. Connect a voltmeter from the regulator (A) terminal to the regulator base. Operate the generator at a medium speed and perform the following tests:

a. Operation.— Read the voltmeter.

Effect.—

1. Voltage builds up.
2. Voltage does not build up.

Cause and Remedy.—

1. Open series circuit. See test (b).
2. Regulator out of adjustment, field circuit open, grounded field or series circuit. See test (c).

b. Operation.— Remove the regulator cover and with the generator operating at a medium speed hold the circuit breaker contacts closed.

Effect.—

1. Ammeter shows charge.
2. No generator output.

Cause and Remedy.—

1. Open circuit breaker shunt winding, incorrect setting of circuit breaker or dirty contacts. Clean contacts and reset circuit breaker as in the operation test under 1000 hour tune-up inspection. If the circuit breaker cannot be set the shunt coil is open and the regulator should be removed for an overhaul.

2. Clean the circuit breaker contacts and try the test again. If there is still no charge the series windings are open and the regulator should be removed for an overhaul.

c. Operation.— Run the generator at idle speed and momentarily connect a jumper from the (A) to (F) terminals.

Effect.—

1. Voltage builds up.
2. Voltage does not build up.

Cause and Remedy.—

1. Open field circuit or regulator out of adjustment. See test (d).
2. Grounded field or series circuit. Remove regulator for an overhaul.

d. Operation.— Operate at medium speed with the jumper removed. Remove the regulator cover and hold the voltage regulator contacts closed.

Effect.—

1. Voltage builds up.
2. Voltage does not build up.

Cause and Remedy.—

1. Voltage regulator contacts burned or dirty or incorrect regulator setting. Clean the contacts and adjust the regulator as in the operation test under 1000 hour tune-up inspection.

2. Clean contacts and try again. If the voltage still does not build up see test (e).

e. Operation.— Remove the regulator cover and hold the current regulator contacts closed.

Effect.—

1. Voltage builds up.
2. Voltage does not build up.

Cause and Remedy.—

1. Current regulator contacts burned or dirty or incorrect regulator setting. Clean the contacts and adjust the regulator as in the operation test under 1000 hour tune-up inspection.

2. Clean the contacts and perform test (e) again. If the voltage still does not build up remove the regulator for an overhaul.

(c). Specifications.—

Volts 24.— Ground Polarity Negative or Positive.

Carbon Resistors 5 used.—

R1 marked 135, resistance 130 to 140 ohms.
R2 marked 11, resistance 10 to 12 ohms.
R3 marked 60, resistance 57 to 63 ohms.
R4 marked 1.4, resistance 1.3 to 1.5 ohms.
R5 marked 50, resistance 47 to 53 ohms.

Circuit Breaker.—

Resistance of voltage winding 215 to 237 ohms.
Armature spring 16 turns.
Armature air gap .0595″ to .0625″ (ST-281-2). Measure with contacts open and Armature against the stop. Gauge should be on the contact side and next to the armature stop pin.
Contact point gap .025″ minimum.
Contacts close 26.0 to 27.2 volts.
Contacts open 1.7 to 3.8 amperes discharge after a charge of 5 amperes.

Current Limiting Regulator.—

Pressure of contact points 7 to 8 ounces.
Armature spring 16 turns.
Armature air gap .047″ to .049″ (ST-281-5). Measure with the gauge on the contact side and next to the brass armature stop pin. The contacts should be closed with the high limit gauge in place and open with the low limit gauge in place.
Contact point gap .030″ to .033″.
Gap between contact spring and armature stop .010″ to .016″.
Operating amperage 9.8 to 10.2 amps.

Voltage Regulator.—

Resistance of main winding 64 to 70 ohms.
Pressure of contact points 7 to 8 ounces.
Armature spring 14½ turns.
Armature air gap .040″ to .042″ (ST-281-1). Measure with the gauge on the contact side and next to the brass armature stop pin. The contacts should be closed with the high limit gauge in place and open with the low limit gauge in place.
Contact point gap .010″ to .012″.
Gap between contact spring and armature top .010″ to .016″.
Operating voltages. Figures given are for a unit in normal operation and charging at ½ maximum capacity.
Allowable variation .40 volts:

Tem. F	50°	60°	70°	80°	90°	100°	110°	120°
Volts —	28.58	28.54	28.50	28.46	28.41	28.37	28.33	28.29

(d). 100 Hour Inspection.—

1. Wiring.— Inspect the wiring between the generator, regulator and battery for broken wires and high resistance connections. Pay special attention to the ground connections at all three units.

Connect a reliable ammeter, with 1 ampere graduations, in series with the regulator (B) terminal and the lead removed from this terminal. Run the generator at a medium speed and turn on lights or accessories until the ammeter shows a 5 ampere charging rate. At this charging rate measure the voltage drop between the following points using an accurate voltmeter graduated in .1 volt divisions. The voltmeter should not show a reading above the maximum noted.

a. Generator (A) terminal to regulator (A) terminal — .05 volt max.

b. Generator (F) terminal to regulator (F) terminal — .03 volt max.

c. Battery terminal to regulator (B) terminal — .05 volt max.

d. Regulator ground screw to generator frame — .02 volt max.

e. Regulator ground screw to battery ground post — .02 volt max.

f. Generator frame to battery ground post — .02 volt max.

2. Operation.— Operate the engine at about 2500 generator R.P.M. If the battery is low the ammeter should show a generator output of 10 amperes. If the battery is fully charged the charging rate will be a low sustaining charge. To further check this low charge for correct operation, stop the engine then use the starting motor for 5 to 10 seconds. Restart the engine and note the first charging rate. The ammeter should show a charge of 10 amperes at first and then will gradually decrease as the battery becomes charged.

If the regulator does not function as described above, it should be inspected and adjusted as described in the 1000 hour tune-up inspection.

(e). 1000 Hour Tune-up Inspection.—

1. Preliminary Inspection.—

a. Wiring.— Check the wiring to see that it is properly connected to the generator.

b. Generator Performance.— Make sure the generator operates correctly without the regulator in the circuit. Remove the armature and battery leads from the regulator and connect an ammeter between them. Remove the field lead from the regulator and while operating at idle speed touch the field lead to the armature lead. Increase the speed slowly noting the charging rate. DO NOT INCREASE THE OUTPUT ABOVE THE RATED OUTPUT OF THE GENERATOR. If the generator output will not build up inspect the wiring harness for shorts and opens and remove the generator for an overhaul.

c. Incorrect Regulator.— Make sure the regulator is the correct type for use with the generator.

d. Battery.— Check the specific gravity and terminal voltage of the battery. If the battery is not up to specifications substitute temporarily for test purposes a fully charged battery of the same type and capacity.

e. High Resistance Connections.— Inspect the wiring between the generator, regulator and battery for broken wires and high resistance connections. Pay special attention to the ground connections at all three units.

Connect a reliable ammeter with 1 ampere graduations in series with the regulator (B) terminal and the lead removed from this terminal. Run the generator at a medium speed and turn on lights or accessories until the ammeter shows a 5 ampere charging rate. At this charging rate measure the voltage drop between the following points using an accurate voltmeter graduated in .1 volt divisions. The voltmeter should not show a reading above the maximum noted.

1. Generator (A) terminal to regulator (A) terminal — .05 volt max.
2. Generator (F) terminal to regulator (F) terminal — .03 volt max.
3. Battery terminal to regulator (B) terminal — .05 volt max.
4. Regulator ground screw to generator frame — .02 volt max.
5. Regulator ground screw to battery ground post — .02 volt max.
6. Generator frame to battery ground post — .02 volt max.

2. Test Procedure.—

a. Circuit Breaker.—(end unit — with heavy wire winding). Connect a reliable ammeter in series with the regulator (B) terminal and the lead removed from the terminal. Connect an accurate voltmeter from the regulator (A) terminal to the regulator ground screw and hang a reliable thermometer near the regulator (about 2 inches from the regulator cover but not touching the regulator.)

Disconnect the field lead from the regulator (F) terminal and insert a variable resistance (3 amp.-50 ohm capacity) between the lead and the regulator terminal.

Run the generator at about 1000 generator R.P.M. Insert all the resistance in the field circuit, then slowly reduce the resistance noting the voltage reading just before the change caused by the closing of the circuit breaker. Increase the charging rate to the figure specified for the regulator being tested then reduce the charging rate by inserting resistance in the field circuit. Note the amperage discharge just before the circuit breaker opens and the ammeter reading drops to zero. The closing voltage and the opening amperage should be within the limits specified for the regulator being tested.

An accurate method for noting the exact instant of opening or closing of the circuit breaker is to connect a headphone (2000 ohms or higher) to the battery and armature terminals of the regulator. When the contacts open or close a click will be heard in the headphone.

To adjust the closing voltage change the armature spring tension by adjusting the thumb nut at the lower end of the spring. Increase the spring tension to raise the closing voltage or decrease the tension to lower the voltage. To adjust the opening amperage raise or lower the stationary contacts keeping the contacts perfectly aligned. Increasing the contact gap reduces the opening discharge amperage. Change the contact gap by bending the stationary contact brackets keeping the contacts aligned so that contact is made on both sets simultaneously. Do not adjust the gap between the contacts to less than .025″.

b. Voltage Regulator.—(end unit—with fine wire winding). Connect the ammeter as noted above and connect the voltmeter from the regulator (B) terminal to the regulator ground screw. Remove the variable resistance from the field circuit.

Run the generator at ½ maximum output for 25 minutes to make sure the regulator is at normal operating temperature. Have the cover on the unit during this warm up period.

Stop the engine then bring it to approximately 2500 generator R.P.M. Adjust the amperage to ½ maximum output by turning on lights or accessories and then note the voltmeter reading. This reading should be within the limits specified for the voltage regulator operation. To adjust the operating voltage change the armature spring tension by turning the thumb nut on the lower end of the armature spring. After each adjustment stop the engine then restart it. Bring it up to speed and adjust the current before taking a reading.

In order to obtain an accurate indication of the operation of the voltage regulator unit connect a headphone (2000 ohms or higher) between the (F) terminal and ground to pick up the sound of the opening and closing of the contacts. The clicks should be regular and clear without irregularities or missing. If the tone is not clear and regular, remove the regulator cover and inspect the contacts. The contacts should be flat and not burned excessively and should be aligned to make full face contact. If the contacts need cleaning, refer to paragraph for the method.

c. Current Regulator.—(center unit — with heavy wire winding). Connect the regulator and instruments as described above for the voltage regulator and run the generator at approximately 3000 generator R.P.M. Turn on lights and accessories so that the generator must charge at its maximum rate. The ammeter should show a reading within the limits specified. To adjust the operating amperage change the armature spring tension by turning the adjusting nut at the lower end of the armature spring. After each adjustment stop the engine then restart it. Bring the engine up to speed and take an ammeter reading. Have the cover on the unit when taking readings.

In order to obtain an accurate indication of the operation of the current regulator unit connect a headphone (2000 ohms or higher) between the regulator (F) terminal and ground to pick up the sound of the opening and closing of the contacts. The clicks should be clear and regular without irregularities or missing. If the tone is not clear and regular remove the regulator cover and inspect the contacts. The contacts should be flat and not burned excessively and should be aligned to make full face contact. If the contacts need cleaning refer to paragraph (d) for the method.

d. Contacts.— Inspect the contacts on all three units. In normal use the contacts will become frayed. If the contacts are burned or dirty or if they are not smooth file the contacts with a No. 6 American Swiss cut equalling file. Move the file parallel and lengthwise to the armature. File just enough so that the contacts present a smooth flat surface toward each other. It is not necessary to remove every trace of burning. After filing, dampen a piece of linen tape in refined carbon tetrachloride and draw the tape between the contacts. Repeat with a dry piece of tape. Use a clean piece of tape for each set of contacts.

e. Recheck.— Operate the unit at ½ maximum output for 5 minutes with the cover on the regulator. Repeat the testing procedure for all units as described in paragraphs a, b and c above.

(e). Overhaul Procedure.— If the regulator cannot be adjusted to the correct specifications on the above operation test it should be removed and the following tests made with the proper equipment.

1. Preliminary Visual Inspection.— Before making any of the following tests or adjustments it is recommended that a close visual inspection be given the regulator with special emphasis being paid to the following points:

a. Broken regulator seal.

b. Evidence of burning or abnormal high temperature at the coils, contacts, insulation, contact springs, external terminals or any other point. (It is recommended that this test be made with a magnifying glass.)

c. Loose connections which result from poor soldering.

d. Loose nuts on bottom of the magnet cores, loose rivets or screws. All nuts and screws must have lock washers.

e. Loose contacts.

f. Misalignment of contacts.

g. Armature stop rubbing against or interfering with the circuit breaker armature.

h. Bent armature either at the contact or hinge end. (The armature should be perfectly straight from one end to the other.)

i. Field yoke bent.

j. Bent or distorted armature hinges.

k. Reversed bi-metal hinges on the circuit breaker unit. (When correctly installed the brass side must be up.)

l. Stripped or crossed threads on any screw or nut.

m. Corrosion due to salt or acid.

n. Evidence of water having been inside of cover.

o. Incorrect, bent or distorted armature springs. (In case of doubt it is recommended that the spring be replaced.)

p. Broken or altered carbon resistors. See Fig. 120 for correct assembly.

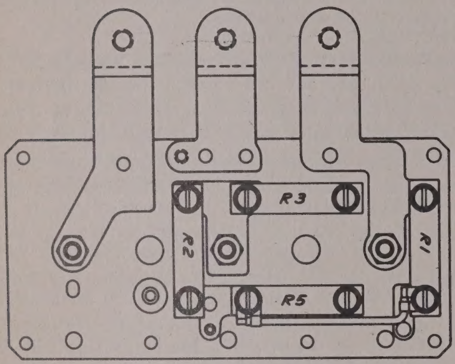


Fig. 120 — Regulator Carbon Resistor Assembly

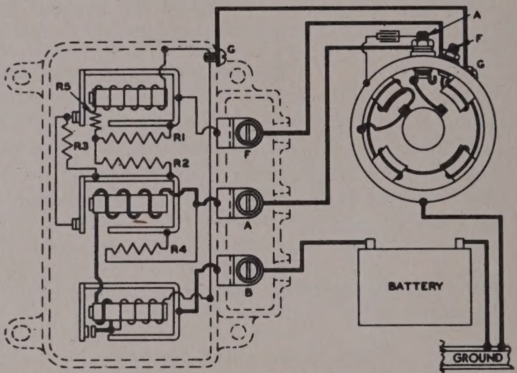


Fig. 121 — Current Voltage Regulator Wiring

q. Broken gaskets.

r. Incorrect wiring connections between units. See Fig. 121.

s. Reversed armature springs. (On regulators using different armature springs for the separate units the size spring is specified on the specification sheets.)

2. Resistance Tests.—

a. Resistors.— Remove the terminal cover from the regulator. Take off the regulator cover and remove the subbase by taking out the holding screws.

Remove the resistances one at a time and check them on an ohmmeter. Replace any that are cracked or not within specifications. Make sure they are reinstalled as illustrated in Fig. 120.

b. Circuit Breaker Shunt Coil.— With an ohmmeter measure the resistance from the shunt coil terminal (that was screwed to the base between the circuit breaker and current regulator) to the circuit breaker stationary contact. Replace the circuit breaker unit if the resistance is not within specifications.

c. Voltage Regulator Coil.— Unscrew the two coil leads from the base and measure the resistance between the leads as shown in Fig. 122. Replace the voltage regulator unit if the resistance is not within specifications. Make sure the leads are re-connected exactly as they were as interchanged leads would reverse the polarity of the windings and make the unit inoperative.

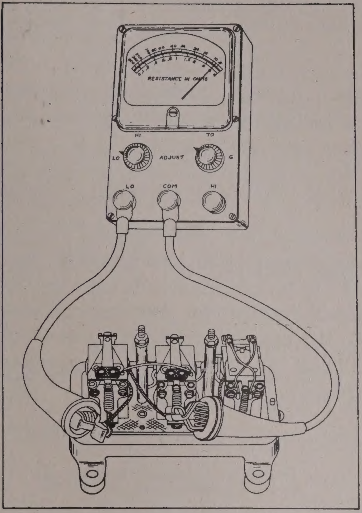


Fig. 122

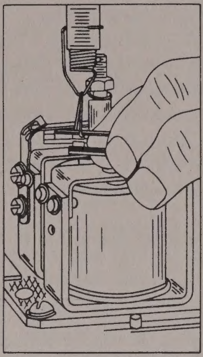


Fig. 123

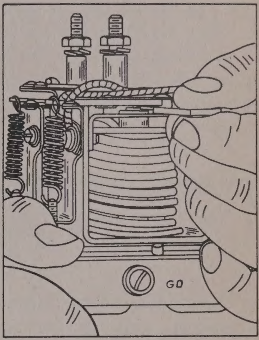


Fig. 124

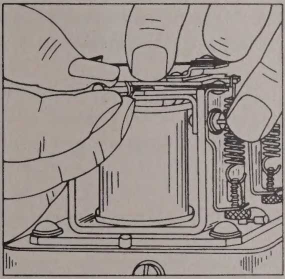


Fig. 126

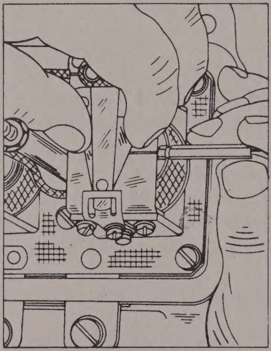


Fig. 125

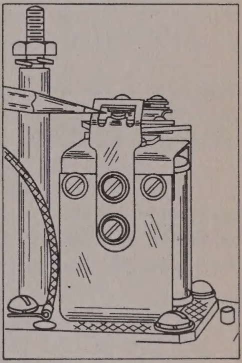


Fig. 127

3. Contact Pressure Tests.—

a. Voltage Regulator.— Connect a battery and a lamp bulb in series with the regulator (A) and (F) terminals. Remove the adjusting nut from the armature spring and take off the adjustable point stop. Hold the armature firm, with a spring scale hooked at the upper contact, pull the contacts apart as illustrated in Fig. 123. Take the reading just as the contacts separate as indicated by the light going out. If the tension is not between 7 and 8 ounces replace the regulator armature. When re-assembling the armature stop, make sure the fibre bumper block is in place.

4. Armature Air Gap Tests.—

a. Circuit Breaker.— Use proper gauge inserted between the armature and magnet core next to and on the contact side of the brass pin in the core. See Fig. 124.

Adjust by bending the armature stop making sure the stop does not interfere with the armature movement.

b. Voltage Regulator.— Use pin gauge inserted on the contact side and next to the brass pin in the core as shown in Figs. 125 and 126, Page 127. The contacts should be closed when the high limit gauge is in place and open when the low limit gauge is in place. Apply pressure near the center of the armature when measuring the air gap but be careful that the contact spring is not touched. Adjust the gap by raising or lowering the contact spring stop.

To indicate when the contacts are closed or open connect a test light in series with the (F) terminal, (A) terminal and a battery. The light will burn brightly when the contacts are closed and will go out or dim when the contacts are open.

c. Current Regulator.— Measure as described for the voltage regulator using the correct gauge specified on the specification sheet.

5. Gap Between Contact Spring and Armature Stop Tests.—

a. Voltage Regulator.— Hold the armature down against the core stop pin and with a feeler gauge measure the gap (see Fig. 127, Page 127) between the upper contact spring and the armature stop. If the gap is outside the limits inspect the bumper block for damage or for improper assembly. Inspect the armature stop for distortion or incorrect adjustment.

b. Current Regulator.— Check as described above for the voltage regulator.

6. Contact Point Gap Tests.—

a. Circuit Breaker.— With spring tension on the armature and with the armature against the stop measure the gap between the contacts with a flat feeler gauge. This gap should be .025″ minimum but may be larger than this after completing the adjustment of the circuit breaker opening amperage. Adjust the contacts so that both sets make and break contact at the same instant.

b. Voltage Regulator.— The specifications for this measurement are approximate only. Make sure the bridge carrying the nickel iron magnetic shunt has been pushed down in assembly and does not interfere with the armature. Too much variation in the contact gap indicates wrong length armature stop pin and the unit should be replaced.

c. Current Regulator.— Check as described above for the voltage regulator.

7. Reassembly.— When all preceding checks and adjustments have been completed, all leads which have been disconnected either by the removal of a screw or by unsoldering should be reconnected. Where resoldering is necessary care must be taken that a good clean contact is made. Do not use acid or paste for solding flux. Use a rosin and alcohol solution.

After the regulator is completely reassembled, its base should be struck sharply on the bench several times to be sure all parts are settled in place. Be sure to strike the base equally so as not to damage the mounting lugs.

8. Polarization.— After the regulator is connected to the generator and battery and before any runs are made, the generator should be polarized with the battery. Make a momentary connection with a jumper from the battery terminal to the generator (A) terminal.

If the generator is not polarized after having been disconnected it may cause the circuit breaker armature to vibrate and burn the contacts.

(5). Batteries.— The battery terminals should be scraped bright and clean at least each 300 hours of operation. After cleaning, a film of heavy grease should be applied to the connections to prevent corrosion.

If it becomes necessary to give a freshening charge make certain the positive terminal of the battery (marked +) is connected to the positive of the charge circuit, and the negative of the battery (marked —) is connected to the negative of the charge circuit. The charging rate for this particular battery is 13 amps.

The electrolyte level rises on charge due to gas bubbles. With vent plug tightly in place, a vent is opened on under side of cover that allows normal expansion of the electrolyte and prevents flooding of the cells. When the plug is removed for hydrometer readings during charge, electrolyte may rise in filling well. PROMPTLY take hydrometer reading. To return electrolyte to cell, it may be necessary to open valve by pressing down and tilting lead ring in well with a small piece of wood. Replace vent plug promptly.

Charge until four consecutive hourly readings show no rise in specific gravity for the lowest cell. If the 13 amp. rate is maintained, length of charging time will be at least 12 hours; lower rates will increase the time proportionately. If temperature exceeds 110° F, reduce charging rate. If necessary to restore electrolyte level during charge, use only approved water.

After completion of charge, the gravity should be between 1.270 and 1.285 corrected to 77° F and with the level of the electrolyte 3/8″ above the top of the separators. If it is not, adjust by removing some solution and replacing with approved water or electrolyte as required. Charge to mix solution before testing again.

p. Hand Starting System.—

(1). Hand Crank.— The hand crank should not require any service except possibly a few drops of oil which should be placed on the shaft occasionally.

(2). Compression Release Levers.— If a new compression release assembly or a new valve cover is installed, the compression release levers will require adjustment. This may be done as follows:

(a). Screw the new compression release assembly into the valve cover until the shoulder on the body just enters the top of the valve cover.

(b). Place a .025″ piece of steel shim stock between the release lever and the release lever pin as shown in Fig. 128.

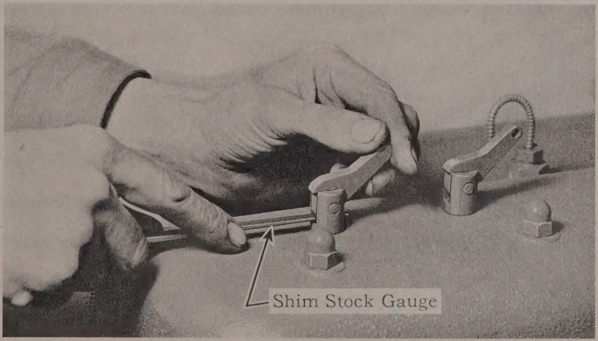


Fig. 128 — Compression Release Adjustment

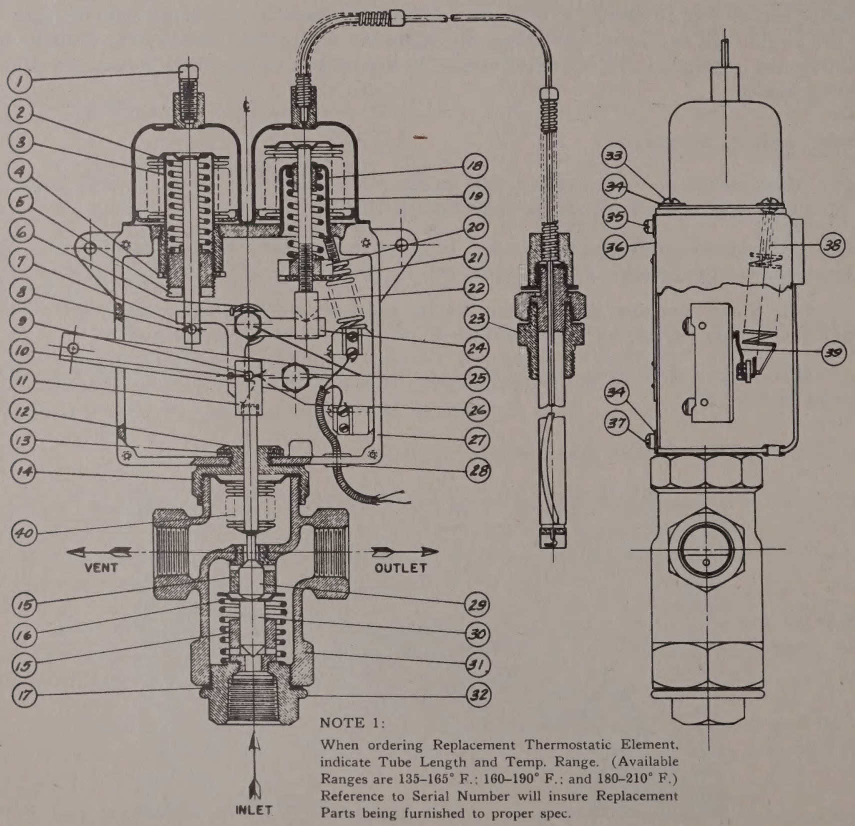
(c). Start the engine.

(d). Screw the release assembly down (with the shim stock in place) until you just feel the valve lever touch the end of the release pin. Remove the shim stock and repeat the above adjustment for each compression release assembly.

Q. Alarm and Protective System.— The safety control should require very little attention or maintenance. There is no oiling required or stuffing box to be packed. Should the pressure element or thermostat become inoperative, it will be apparent immediately due to the shutting down of the engine. It is recommended that occasionally the safety control cover be removed and the mechanism be examined, to see that no parts have been loosened due to vibration. This is especially important in regard to the jam nuts on the adjustments. If it is found that these jam nuts have become loose, these controls should be tested as explained below. If either the thermostat or the pressure element has failed or becomes damaged, replacement will be necessary.

(1). Adjustments.—

(a). Pressure Control.— The pressure element may be checked by stopping the engine and noting the lubricating oil pressure at which the control trips as the lubricating oil pressure falls off.



NOTE 1:

When ordering Replacement Thermostatic Element, indicate Tube Length and Temp. Range. (Available Ranges are 135–165° F.; 160–190° F.; and 180–210° F.) Reference to Serial Number will insure Replacement Parts being furnished to proper spec.

Fig. 129 — Safety Control Model 530

The pressure element on this control is adjustable to trip between 5 and 25 pounds lubricating oil pressure and will not be damaged by pressure up to 75 pounds. To raise the tripping pressure, loosen jam nut (4) and turn adjusting nut (5) so that it moves away from the valve. To lower the tripping pressure turn the adjusting nut in the opposite direction. After the desired tripping pressure has been reached, tighten the jam nut (4) so that vibration will not cause the setting to change.

(b). Temperature Control.— To properly check the tripping temperature it will be necessary to remove the thermostat bulb from the engine, place it in a container of water and raise the water temperature until the control trips. With this test, it will be necessary to either have pressure on the lubricating oil pressure element or to remove pin (7) from the control mechanism.

The automatic control can be adjusted to trip at any temperature range specified on the bulb plate. To lower the tripping temperature loosen jam nut (21) and turn adjusting nut (22) so that it moves away from the valve. To raise the tripping temperature turn the adjusting nut in the opposite direction.

(2). Repairs.—

(a). Valve.— Should the valve leak excessively under the seats, remove valve plug (32) which furnishes access to the particular parts. After cleaning, insert the valve poppets and their respective inserts and tap lightly to make the seats tight. It should not be necessary to grind these valves.

Should the packless bellows (40) become broken, it will become evident by leakage of fuel oil thru the valve bonnet into the mechanism housing. To replace packless bellows, remove cover from control housing. Loosen set screw (13) and unscrew lock nut (12) which will allow the valve to be disengaged. Then remove cap nut (14) and lift out damaged bellows. In replacing new bellows lubricate the seating surfaces with oil or other lubricant to prevent galling of the parts when cap nut is tightened.

(b). Pressure Element.— To replace pressure element, remove pin (7) and cap screws (33) which will allow the pressure element to be lifted out. In replacing the new element, it should not be necessary to disturb the original setting.

(c). Thermostat.— To replace thermostat, it will be necessary to remove the pressure element as shown and proceed as follows:

1. Remove cap screw (25) to take off latch (24).
2. Remove (20), (21), and (22).
3. Remove four screws (33) and lift out thermostatic assembly.

To install the replacement thermostat, use the reverse of procedure above. Note that slots in (22) must be flush with the top of angle on thrust stem.

CAUTION: The flexible tubing that connects the thermostat bulb to the thermostat assembly in the safety control must not be cut, kinked or unduly twisted. It may be bent on a 3½″ radius or longer. It should not contact any surface whose temperature might become higher than the temperature for which the control is set to trip.

(3). Removing Safety Control From Engine.—

(a). Disconnect the two wires, at the instrument panel, that lead to the safety control.

(b). Remove the thermocouple from the thermostat housing back of the upper radiator hose connection. Take off the clip that holds the thermocouple line to the side of the cylinder block.

(c). Disconnect the tubing lines between the safety control and the block; between the safety control and the fuel rail and between the safety control and the cartridge type fuel filter.

(d). Remove the two ¼″ capscrews that hold the safety control to the flywheel housing.

(e). You can now lift the safety control off the engine as the base support plug will pull out of the subbase. Care should be taken not to damage the thermocouple and line in any way while lifting the control from the engine.

r. Engine Tune-Up Procedure.— The engine should be given a minor tune-up every 100 hours. Proceed as indicated below:

(1). Remove the injection nozzles. Clean and check each nozzle for dribble and pressure setting. Replace each nozzle and tighten the hold-down nuts evenly.

(2). Remove the valve cover and check the valve clearance. Reinstall the valve cover.

(3). Loosen the backing screws on the governor control rack. Turn these screws in until there is about 1/16″ clearance between the head of the screw and the fuel injection pump control rod.

(4). Remove the exhaust test plugs which are located beneath the exhaust manifold and start the engine.

(5). Run the engine at normal speed with no load and listen to the sound of the exhaust in the test plug holes. If any cylinder is firing light turn the adjusting screw Fig. 99, Page 102, out or, to the left until the exhaust sounds the same as the other cylinders. If any cylinder should be firing heavy, turn the adjusting screw in or to the right. When the firing balance is correct all of the cylinders should sound even and the engine should run with a steady rhythm. Replace the exhaust test plugs.

(6). Readjust the backing screws on the governor control rack until there is .005″ clearance (use a feeler gauge) between the head of the screw and the end of the fuel injection pump control rod. See Fig. 99, Page 102.

(7). Apply load to the engine and set the engine speed to 1200 revolutions per minute. This should be done as described under "Governor Adjustments." If no revolution counter is available the speed may be set by adjusting the governor until the frequency meter on the switchboard shows exactly 60 cycles per second.

3. GENERATING EQUIPMENT.—

a. Inspection.— The generator and exciter should be examined once each month.

(1). Remove the exciter wrap-around cover (45) Fig. 39, Page 42.

(2). Inspection while the set is stopped.

(a). Wipe out any accumulation of greasy dirt with carbon tetrachloride or equivalent.

(b). Blow out with a medium blast of dry, compressed air. Blow dirt away from the windings, not into them.

(c). Examine the brushes.

1. Check to see that the pigtails are securely fastened to the brush holders for good contact.

2. Check the exciter brush rigging for proper setting as illustrated by Fig. 130, Page 133.

3. Brushes should move freely in their holders.

4. Brushes should have a good contact surface with the collector rings and commutator along the whole brush face.

5. Adjust the spring tension according to brush wear. Generator brushes are designed to have a wearing depth of approximately ¾″. The lever assembly and spring are so designed that, for each ¼″ of brush wear, correct brush pressure can be maintained by moving the spring arm one notch.

6. If the brushes are worn so that correct pressure cannot be maintained by this adjustment, install new brush assemblies and adjust the springs to a position of least tension. Be sure the brushes face the correct way to fit the collector ring or commutator contour.

7. Exciter brushes must be replaced before they are worn so short that the springs rest on the brush holders instead of on the brushes.

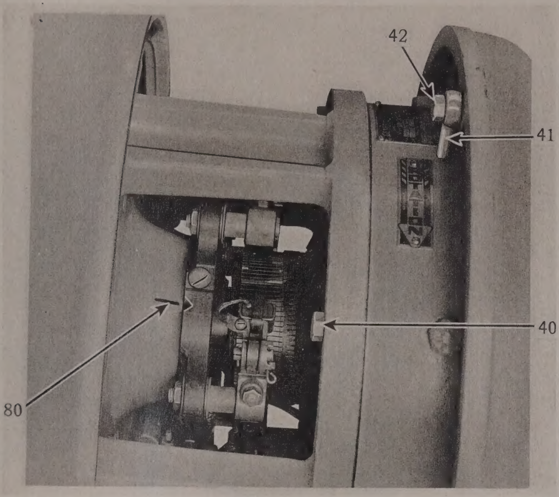


Fig. 130 — Exciter Brush Rigging Setting

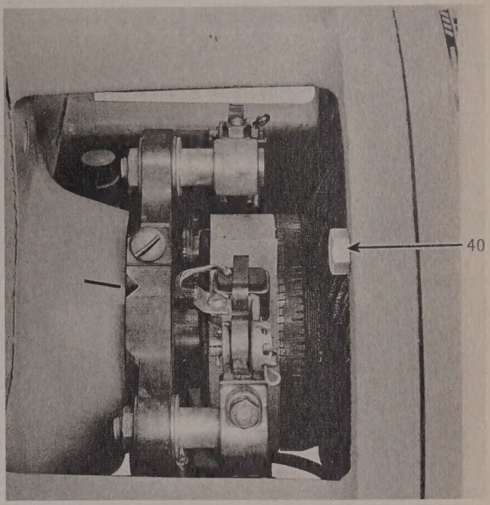


Fig. 131 — Sanding Exciter Brushes

8. Sand new brushes with a narrow strip of grade 00-E(2-O-E) sandpaper wrapped around the commutator, see Fig. 131. Never use emery cloth. Release engine compression and spin the rotor several times with the crank or until the brushes fit the commutator curvature.

9. Whenever new exciter brushes are installed, stone the commutator as given in paragraph (f), immediately following.

(d). If the collector rings are severely grooved, they should be replaced, or serviced as follows:

1. Disassemble the exciter and generator.

2. Place the rotor assembly in a lathe.

3. Turn the collector rings to restore smooth and true surfaces.

4. Polish the surface with an extra fine grade of emery cloth.

5. Blow away all dust.

(3). Inspection while the set is operating.—

(a). Check exciter commutation.

(b). Check sparking of the generator brushes.

(c). For excessive sparking remedies, see "Troubles and Remedies."

(d). If the commutator is black or dirty, it should be wiped with a piece of dry canvas or other hard, non-linting material wound around a block of wood held against the commutator as it rotates.

(e). Dirty collector rings may be cleaned with carbon tetrachloride or equivalent.

(f). Hold a small stick firmly on an exciter brush or spring to check for commutator roughness and eccentricity. Remedy roughness by stoning with an abrasive "Commstone," Grade F, as manufactured by the Martindale Electric Company, Cleveland, Ohio, or an equivalent.

1. To prevent copper dust from entering the generator, close the air intakes as indicated with cardboard (74) Fig. 132.

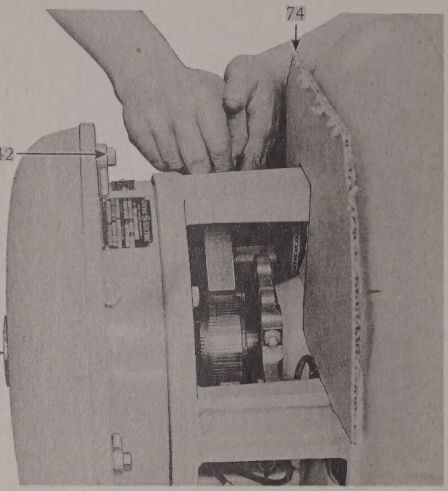


Fig. 132 — Stoning Exciter Commutator

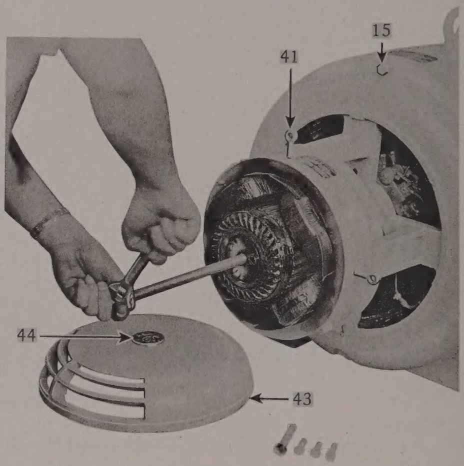


Fig. 133 — Removal of Exciter Rotor Assembly

2. Lift all exciter brushes and slip them under their springs.

3. While the power unit is operating without load, hold the stone lightly against the commutator, using a brush holder as a rest, see Fig. 132.

4. Stone the commutator just enough to remove the rough spots, pitted areas, or slight eccentricity.

5. The commutator should not be stoned or worn down to less than 3½" in diameter. Replace the exciter armature, if the commutator diameter is below this limit.

6. After stoning, undercut the mica at least 1/32" with a sharp hooked knife.

WARNING: Do not scratch the commutator bars.

7. Blow away all copper dust and mica.

8. Remove the covering (74) Fig. 132 from the air intake of the generator.

b. Disassembly.—

(1). Exciter.—

(a). Remove the exciter wrap-around cover.

(b). Remove the end shield (43) Fig. 133.

(c). Remove the exciter brushes from their brush holders, turn them to a horizontal position, and insert them between the brush holders and springs. NOTE: To disconnect the pigtails from brush holders is unnecessary.

(d). Remove the exciter rotor assembly as illustrated by Fig. 133, Page 134 and Fig. 134.

1. Fig. 133, Page 134 shows one method of performing this operation.

2. Fig. 134 shows the details and dimensions of the tool to be used for this operation.

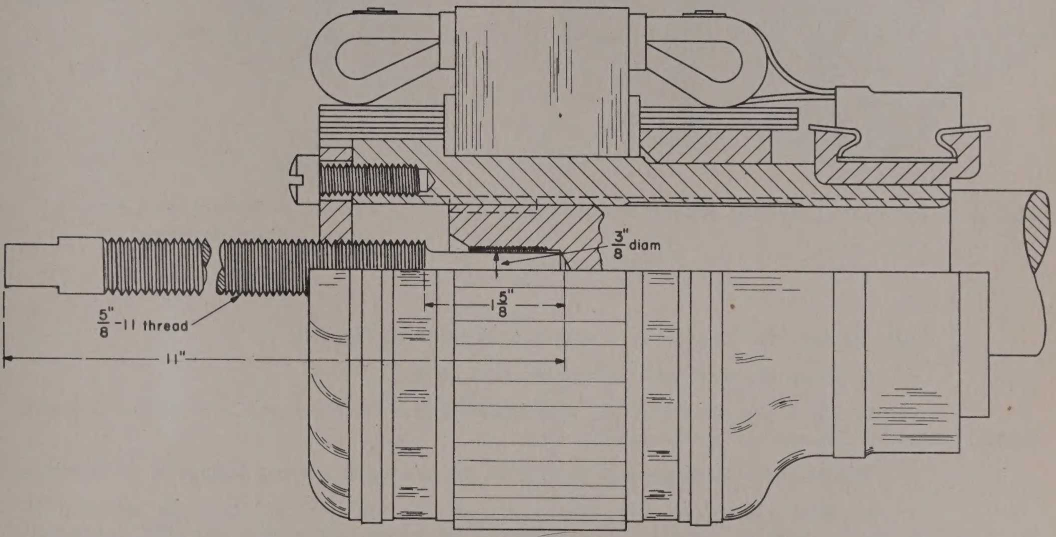


Fig. 134 — Exciter Rotor Assembly Removal

(2). Generator.—

(a). Lift and block up the generator brushes, using the same method as used for the exciter brushes.

(b). Remove the bearing bracket and adapter cover.

(c). Remove the bearing bracket and adapter (13) Fig. 135, Page 136.

1. Remove the eight bolts (15).

2. Loosen the bracket and adapter by light tapping.

3. If the bracket sticks, it may be backed off as illustrated by Fig. 135, Page 136, using two of the eight bolts. Two tapped holes are provided for this operation.

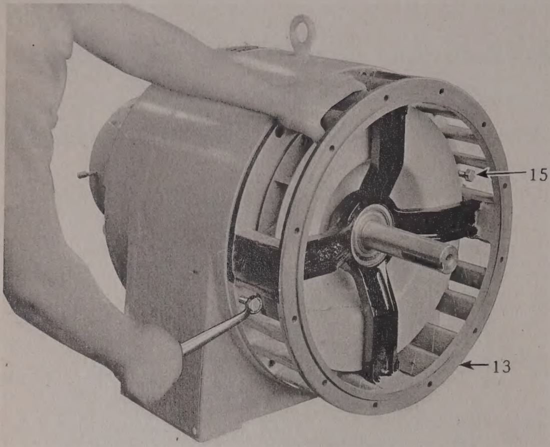


Fig. 135 — Removal of Bearing Bracket and Adapter

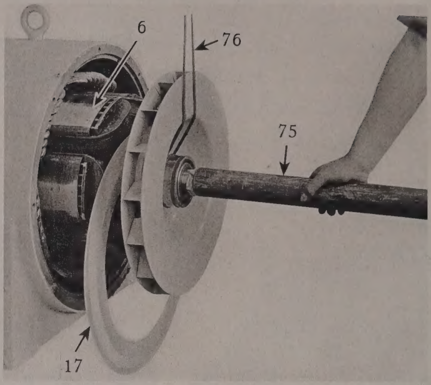


Fig. 136 — Removal of Generator Rotor Assembly

(d). Remove the complete rotor assembly as shown in Fig. 136.

1. Wrap the shaft with several layers of cloth.

2. Slip a pipe (75) Fig. 136, approximately four feet long and from two to two and one-half inches in diameter, on the wrapped shaft.

WARNING: Keep the pipe away from the bearing to prevent damage to the bearing.

3. With a sling (76) Fig. 136, suspended from an overhead crane (as indicated in Fig. 136) and pressing down on the pipe, counterbalancing the weight of the rotor assembly, slowly pull the rotor assembly (6) out of the stator frame.

WARNING: Take care not to damage any windings or the bearing.

c. Exciter Field Coil Replacement.—

(1). Remove connection clips from the coil to be replaced.

(2). Remove the cap screw (37) Fig. 36, Page 39 which holds the pole (34) to its magnet frame.

(3). The coil (36), shim (35), pads (38), and pole can be easily pulled out.

(4). Push the pole out of its coil and insert it into a new coil.

(5). Replace the pads.

(6). Hold the assembly in position and partially insert the capscrew (37).

NOTE: The coil shape must fit the magnet frame contour. The coil must be inserted for correct polarity, see paragraph (9) of this section.

(7). Replace the shim (35) between the pole and magnet frame.

(8). Tighten the cap screw (37).

(9). Coil leads are stamped with an "I"or an "O". Connect the coils as follows:

(a). "I" lead of one coil to an "I" lead of the adjacent coil.

(b). The "O" lead of the same coil to an "O" lead of the adjacent coil. See Fig. 137.

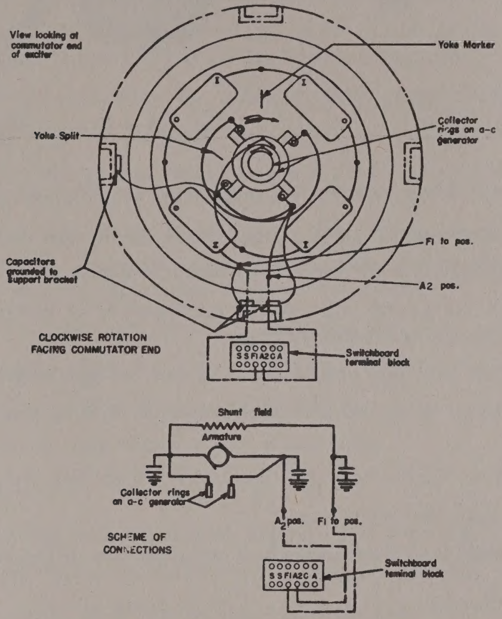

View looking at commutator end of exciter
Yoke Marker
Collector rings on a-c generator
Yoke Split
F1 to pos.
Capacitors grounded to support bracket
A2 pos.
CLOCKWISE ROTATION FACING COMMUTATOR END
SSF1A2CA
Switchboard terminal block
Shunt field
Armature
Collector rings on a-c generator
A2 pos.
F1 to pos.
SCHEME OF CONNECTIONS
SSF1A2CA
Switchboard terminal block

Fig. 137 — Connection Diagram for Exciter

d. Bearing Lubrication.—

(1). Bearing Removal.—

(a). Remove the bearings with a bearing puller such as is illustrated in Fig. 138, Page 138.

(b). The puller should be made to clamp around and behind the bearing and to exert an even pressure.

(c). To prevent damage to the shaft, insert a piece of soft metal (77) Fig. 138, Page 138, such as copper, between the shaft and the bolt of the puller.

(2). Greasing.—

(a). The cartridge-type ball bearings are packed and sealed with sufficient grease to give at least 8,000 hours or two years of normal operation. After this period or at a time coinciding with the diesel engine overhaul, clean and repack the bearings.

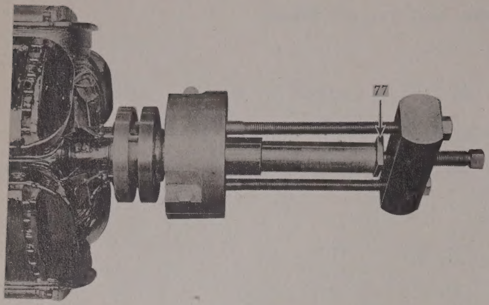


Fig. 138 — Bearing Puller

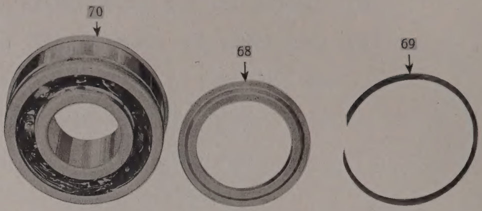


Fig. 139 — Bearing Disassembled for Greasing

(b). With a screw driver remove the snap rings, see Fig. 139.

(c). Carefully remove grease seals (68) with a small, thin knife blade or equivalent.

WARNING: Damage to seals results in leakage of grease.

(d). Clean out all old grease with carbon tetrachloride or equivalent. Never allow this solvent to come in contact with the insulated windings.

(e). Flush the ball bearings with a small amount of light engine oil.

(f). Fill the bearings to ½ of their total capacity with grease recommended by the bearing manufacturer.

WARNING: Never fill the bearings completely. Never use ordinary cup greases.

(g.) Replace the seals and snap rings.

(3). Bearing Reassembly.— Two methods of replacing new or regreased bearings are recommended.

(a). Heating Method.—

1. Heat the bearing in an oven to approximately 250 degrees F.

2. Quickly slide the bearing into position on the shaft.

(b). Pressure Method.—

1. Slide the bearing on the shaft as far as possible.

2. Drive the bearing onto its seat by hammering a sleeve which is placed over the shaft and which will press only on the inner race of the bearing. A few drops of lubricating oil on the shaft will facilitate the procedure.

WARNING: Never hammer directly on the bearing.

e. Collector ring replacement.—

(1). When collector rings are worn or damaged beyond repair, replace them.

(2). Disconnect leads to the generator rotor poles.

(3). Two methods of removing rings are suggested. The saw method may be used for collector rings not to be used again. Use the pull method for rings which will be pressed back on the shaft.

(a). Saw Method.—

1. Cut the rings with a hack saw at diametrically opposite sides.

2. Remove the shell by filing at diametrically opposite sides with a rasp or wood file.

WARNING: Care must be exercised not to damage the shaft or injure the coils.

(b). Pull Method.—

1. Make and use a tool like that shown in Fig. 138, Page 138.

2. The puller must, however, be large enough to fit over the collector rings and so constructed that pressure is exerted only on the collector ring shell.

(4). Press new collector rings into place. A force of approximately one ton is required.

(a). Slip the rings on the shaft.

(b). Slide a steel sleeve 12 inches long and 2¾ inches inside diameter over the shaft and against the collector ring shell.

(c). With one end of the sleeve held against a fixed support, exert force against the shaft extension at the fan end. To prevent damage to the other end of the shaft or to the keyway, use a block of hard wood or a piece of copper placed against the shaft.

(d). Place the rotor assembly in a lathe and check the ring surface for alignment.

(e). If necessary, turn them down until they run true.

(f). Polish the surfaces with extra fine emery cloth.

(g). Remove the rotor assembly from the lathe.

f. Fan Replacement.—

(1). Pull the bearing with a puller as illustrated in Fig. 138, Page 138.

(2). Drill and tap two holes diametrically opposite each other in the fan hub.

(3). Use a fan puller as shown in Fig. 140, Page 140.

(a). Clean engine oil swabbed on the shaft will facilitate fan removal.

(b). Turn nuts with a long-handled wrench.

(c). Tension on the two studs should be kept uniform by alternately tightening each nut the same amount.

(4). Press the fan on with a pressure of five tons or more.

(a). Swab the shaft and the inside of the fan hub with clean engine oil.

(b). The use of a steel sleeve 12 inches long and 2¾ inches inside diameter placed against the inner hub only is recommended.

(c). Protect the opposite end of the shaft with a copper plate or equivalent.

g. Generator Rotor Pole Replacement.—

(1). Remove the fan as detailed in the preceding paragraph.

(2). Collector rings need not be removed for this operation. However, special care must be taken to prevent damaging them. A thick piece of leather or composition rubber laid across them provides adequate protection.

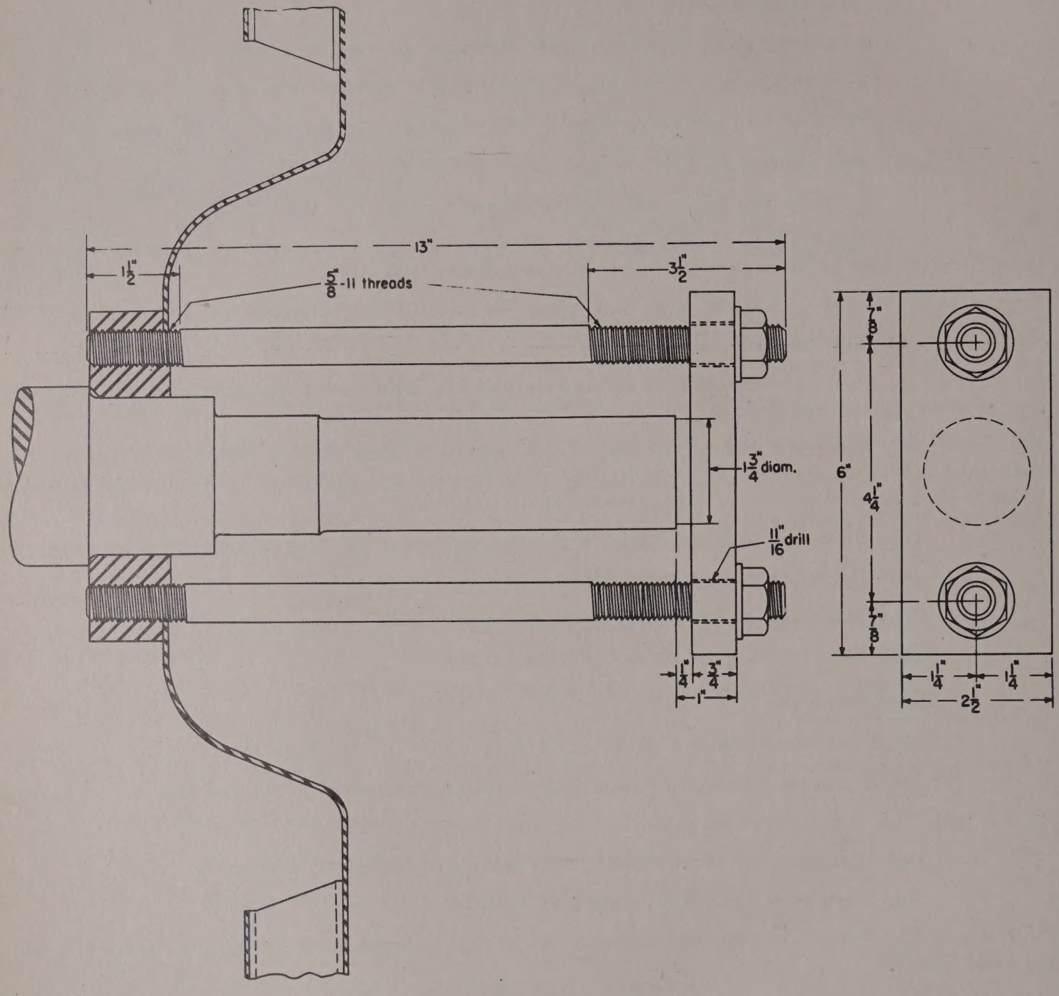

13"
1 1/2"
5/8"-11 threads
3 1/2"
1 3/4" diam.
11/16" drill
1/4"
3/4"
1"
6"
7/8"
4 1/4"
7/8"
1 1/4"
1 1/4"
2 1/2"

Fig. 140 — Generator Fan Puller

(3). Remove the rotor poles with coils as follows:

(a). Place the rotor assembly in fixtures similar to those illustrated in Fig. 141, Page 141.

1. Note that the two uprights are lined with leather (78) Fig. 141, Page 141.

2. The pole to be removed is in a vertical position and is held rigid by an overhead press of at least 500 pounds capacity.

(b). With a hard steel drift and hammer drive out the pole key from the fan end of the rotor assembly, see Fig. 141, Page 141.

1. The drift should have a rectangular cross section of ½" x 7/32" and should be about 10" long.

2. To make sure the key (8) Fig. 142 is being driven in the correct direction, look for a slight taper toward the fan end of the key. The opposite end will be slightly battered from the original assembly. Never drive out the key from this end.

(c). Unsolder the connections between adjacent poles and slide the pole out of its dovetailed slot in the spider, see Fig. 142, (79).

(4). When inserting a new pole into the slot observe the following points carefully.

(a). The new pole must be inserted for correct polarity.

1. Note the appearance of the coils at both ends.

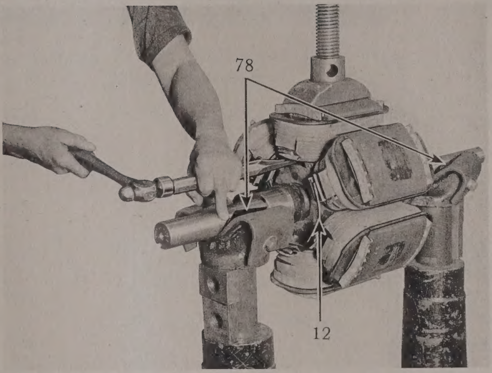


Fig. 141 — Driving Out Pole Key

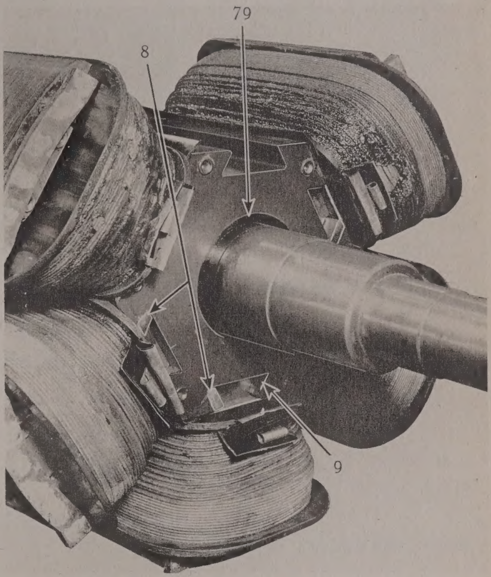


Fig. 142 — Pole Removed from Rotor Assembly

2. Match the new pole and coil with the others, see Figs. 141, 142 and 143, Page 142.

(b). The center line of the pole should be set at 8⅜″ from the bearing shoulder of the ball bearing nearest the collector rings, see Fig. 39, Page 42.

(c). Insert the shim (9), Fig. 142.

(d). Insert the pole key as far as possible. Fig. 143 indicates the key should be driven in from the collector-ring side.

(e). Drive the key completely in, using the same method as used for driving out the key. However, the drift for this operation does not need to be of any special size.

(5). Solder the leads from coil to coil, see Figs. 141, 143, Page 142, (12).

h. Stator Winding Replacement.— In case of damage to the stator windings, replace the entire stator assembly as pictured in Fig. 33, Page 38.

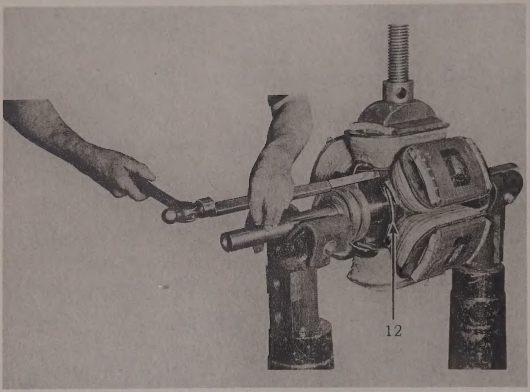


Fig. 143 — Driving in Pole Key

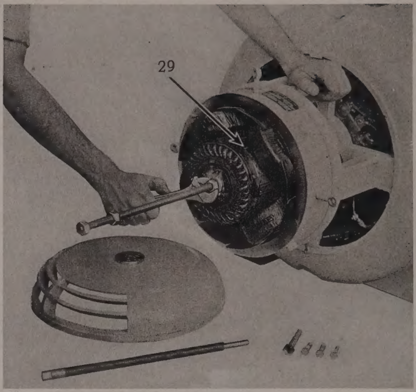


Fig. 144 — Insertion of Exciter Rotor Assembly

i. Reassembly.—

(1). Generator.—

(a). Rotor Assembly.—

1. Remove the end shield and extension.

a. Remove the screws.

b. Loosen the end shield by light tapping.

c. If the end shield sticks, back it off using the method illustrated in Fig. 135, Page 136.

2. Insert the rotor assembly into the stator frame, using the same method and equipment indicated by Fig. 136, Page 136.

a. Be sure the air baffle is in its correct relative position, see (17) Fig. 31, Page 27 and Fig. 136, Page 136.

b. After the rotor assembly is almost in its proper position, the air baffle (17) should be inserted in the rabbet of the stator frame.

c. Move the rotor assembly farther into the stator until there is a minimum clearance of ½″ between the fan and the baffle.

(b). Place the end shield and extension into position on the bearing and insert the bolts, taking care not to damage the brush holders and making certain that the brushes are blocked, up in their holders. A sling (suspended from a crane) around the end shield will aid in lining up the bolt holes.

(c). Assemble the bearing bracket and adapter to the stator in the same manner.

(2). Exciter.—

(a). After blocking up the exciter brushes, insert the exciter armature (29) as illustrated in Fig. 144 and Fig. 145, Page 143.

1. Fig. 144 shows one method of performing this operation.

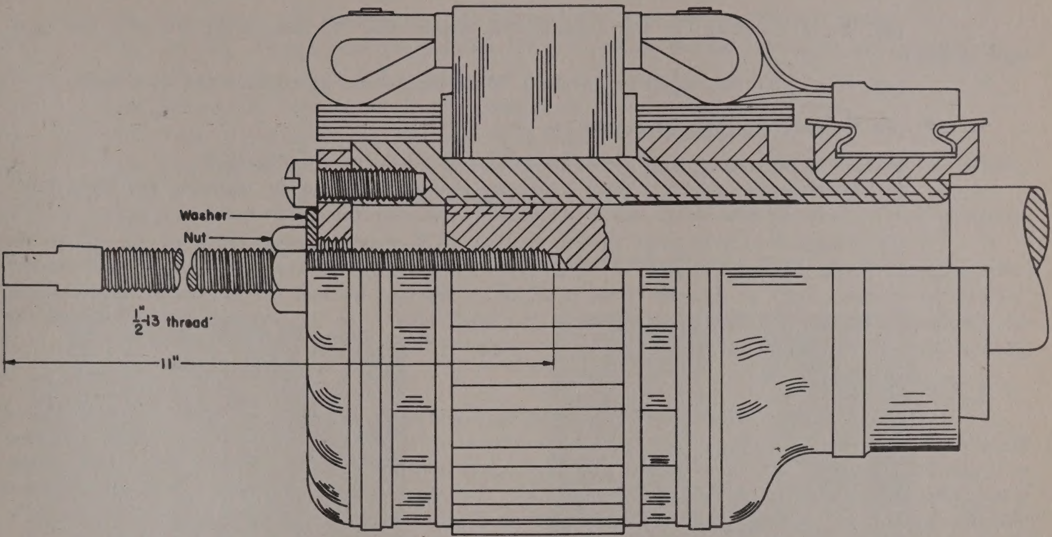


Fig. 145 — Install Exciter Armature

2. Fig. 145 gives details and dimensions of the tool used for this operation.

(b). Insert all brushes into their respective holders.

(c). Replace the exciter end shield.

(d). Replace all covers.

4. SWITCHBOARD.— In order to obtain satisfactory operation from the switchboard, it must have adequate care and periodic inspection. The inspection should cover all devices and connections. While making these inspections, extreme care should be exercised so that the inspector will experience no personal harm. CAUTION: Always shut down engine unit and disconnect engine batteries while making inspections, or tightening connections.

In general, a light monthly inspection and a thorough semi-annual inspection should be a minimum. Keep switchboard clean, wipe off daily. No lubrication is necessary on any of the operating mechanisms. Due to the delicate construction of the circuit breaker, voltage regulator, and meters, it is recommended that major repairs should not be attempted in the field.

a. Voltage Regulator.— The position of the regulator polarity reverse switch should be changed each day; that is, up one day and down the next. It is usually found to be best practice to change the polarity before starting the unit up each day.

If the regulator contacts become so irregular as to hinder operation, use about a 600 grade of carborundum paper or cloth and polish the surfaces. Before operating the regulator, blow the carborundum dust out and wipe off each contact with a piece of clean cloth.

(1). To Remove Voltage Regulator.—

(a). Remove the covers from the regulator.

(b). At the terminal block in regulator, disconnect the four wires that connect the regulator to the terminal block and small resistor on the back of the switchboard.

(c). Unsolder shield wired from grounding terminal.

(d). From the front of the switchboard remove the four mountings that hold the regulator in place.

(e). Now pull the regulator forward, being careful not to damage the wire leads.

(2). To Replace Voltage Regulator.—

(a). Feed the four wires thru the hole in the back of the regulator.

(b). Replace the two left hand mounting screws. Then while replacing the right hand screws, be sure to have the wire cleats that hold the two wires from the circuit breaker in place.

(c). Connect the two leads marked "A" and "C" at the terminal block on the rear of the panel to the terminals marked "A" and "C" on terminal block in the regulator. Connect the lead marked "A2" at the terminal block at the rear of the panel to the terminal marked "M" on the terminal block in the regulator. Connect the remaining lead from the small resistor to the terminal marked "O" on the terminal block in the regulator.

b. Field Rheostat.—

(1). Care of the Rheostat.— Examine the rheostat occasionally to detect any loosening of the nuts or set screws. To remove the rheostat for repairs or replacement, be sure that wires connected to it are disconnected. Then remove the three acorn nuts that hold the rheostat in place and swing the wire under the top nut, out of the way. Now remove the two remaining hex. nuts on the top stud and pull the rheostat off. When replacing the rheostat on the switchboard, be sure the rheostat coupling is properly engaged with coupling disk and the hand wheel coupling.

c. Current Transformer.— All connections on the current transformers, both primary and secondary should be kept tight. A loose connection on the secondary may very seriously interfere with the accuracy of the transformers, because of the extra burden imposed on the transformers by the high resistance joint. If a transformer is damaged in service, it should be removed from the circuit and a new one put in its place. To remove a current transformer from the switchboard:

Metering Current Transformers:—

(1). Disconnect the small secondary leads.

(2). Remove bolts from the primary leads.

(3). Remove the four mounting screws that hold the transformer in place.

(4). The transformer is now free and can be removed.

Cross Current Transformer:—

(1). Disconnect the small secondary leads.

(2). Remove the bolt that connects the one primary lead to the metering transformer below.

(3). Remove the nut from the upper left-hand stud of the breaker which holds the primary lead in place.

(4). Remove the four mounting screws and transformer.

To replace the current transformers, reverse the preceding steps.

d. Circuit Breaker.— To remove the circuit breaker for repairs or replacement, the following instructions should carefully be followed:

(1). Remove the covers from the regulator and loosen the two right-hand mounting screws. These screws hold wire cleats on the back of the panel which hold the two wires from the breaker to the terminal block.

(2). Disconnect the two wires from the breaker that are connected to terminals marked "S" on the terminal block. Slide them out from under the wire cleats.

(3). Disconnect the five small switchboard wires from the circuit breaker and slide them off the breaker studs.

(4). Disconnect and remove the two heavy leads from the top breaker studs.

(5). Remove the cross current transformer in order to free the remaining top breaker stud.

(6). Remove load studs from connection block.

(7). Disconnect and remove copper conductors from lower breaker studs.

(8). Remove the nuts from the four studs that hold the breaker in place.

(9). The breaker is now free and can be removed by pulling it straight back off the studs.

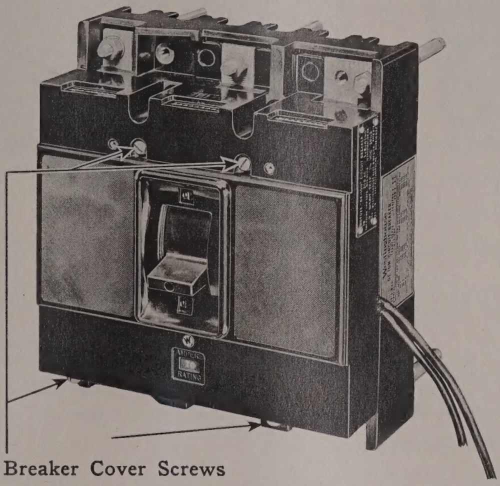


Fig. 146 — Circuit Breaker

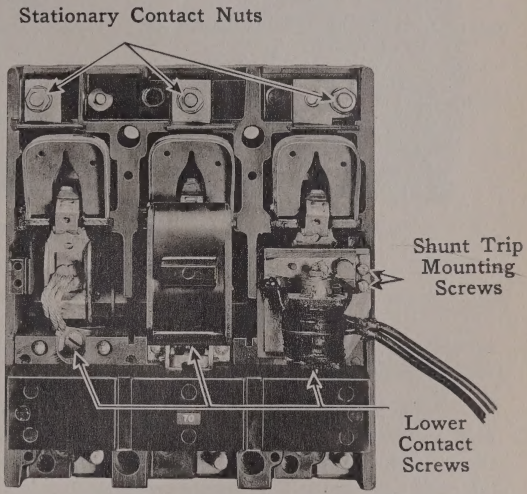


Fig. 147 — Breaker With Cover Removed

To disassemble breaker for repairs or replacement of parts:

(1). To remove breaker cover, remove the four screws as indicated on Fig. 146. The cover can then be lifted from the breaker. (See Fig. 147.)

(2). The moulded handle which is kept in place by the cover can now be taken out.

(3). The shunt trip device can be removed by removing the two screws as indicated on Fig. 147.

(4). The instructions for removing the trip unit complete are supplied by the manufacturer of the breaker and will be found inside the breaker on the trip unit cover. (See Fig. 148, Page 146.)

(5). The two-pole moving contact assembly is held in place by two flathead screws which are located in a rectangular square on the back of the breaker. It will be necessary to remove the compound to find and remove these screws. (Fig. 149, Page 146.)

(6). The arc chambers are also held in place by screws which are compounded in from the back of the breaker. (See Fig. 149, Page 146.)

(7). The stationary contacts are removed by removing the three nuts from the studs.) (See Fig. 147.)

e. Meters:— Repairs on meters should not be attempted because of their delicate mechanisms. It is advised that the meters be returned to the manufacturer for repairs or replacement. Never use the

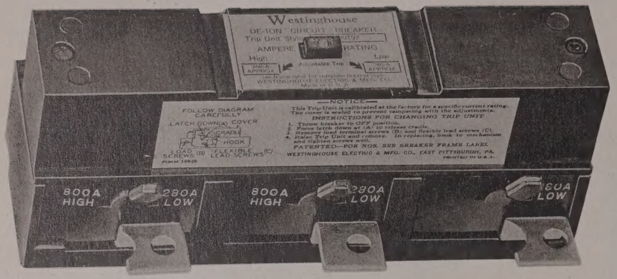
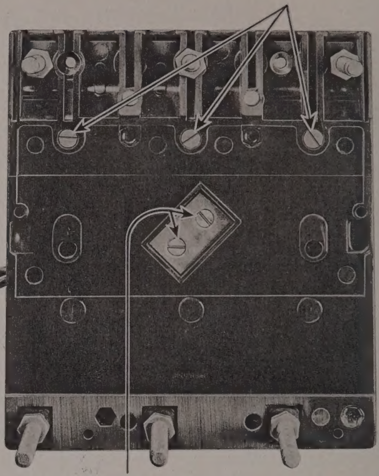

Westinghouse
DE-ION CIRCUIT BREAKER
AMPERE RATING
High
Low
NOTICE
INSTRUCTIONS FOR CHANGING TRIP UNIT
FOLLOW DIAGRAM CAREFULLY
LATCH DOWN (A) COVER
CRADLE
HOOK
LOAD SCREWS (B)
FLEXIBLE LEAD SCREWS (C)
800A HIGH
280A LOW
800A HIGH
280A LOW
LOW

Fig. 148 — Breaker Trip Unit Instructions


Moving Contact Screws

Arc Chamber Screws

Fig. 149 — Circuit Breaker, Back View

switchboard with the A.C. ammeter disconnected from the circuit unless the ammeter switch is on the "OFF" position.

There is one adjustment on the A.C. ammeter and A.C. voltmeter that can be made. That is the zero adjustment screw on the front of the meters. It may be necessary to make this adjustment after the switchboard has been installed or moved. Never attempt to make zero adjustments while the switchboard is operating. The frequency meter has no adjustment.

5. TROUBLES AND REMEDIES.—

a. Engine Won't Start or is Hard Starting.—

(1). No fuel in tank or fuel valve in the supply line from the tank may be closed. REMEDY: Fill the tank or open the valve.

(2). Fuel system not primed. REMEDY: Prime fuel system as described under "Adjustment and Operation."

(3). Engine throttle may be in "OFF" position. REMEDY: Turn the stop lever into the running position.

(4). Batteries too weak. REMEDY: Recharge batteries.

(5). Fuel too heavy to flow thru pipes. REMEDY: Use lighter fuel.

(6). Battery connections corroded. REMEDY: Clean and apply protective grease coating.

(7). Water in fuel. REMEDY: Drain fuel system and supply tanks.

(8). No compression. REMEDY: Check by turning over by hand. Check valves, rings and cylinder walls.

b. Engine is Missing on One or More Cylinders.— At idle speed or at low engine speeds the fuel is not metered as accurately as it is at full load. This causes more or less uneven exhaust and is normal in all respects. Missing under full load, however, may either be regular from certain definite cylinder or cylinders or it may be irregular jumping around from one cylinder to another. In the latter case it might even be one cylinder misfiring erratically.

(1). Regular misfiring is located by loosening the fuel injection tubing nuts, one at a time while the engine is running with a load, and listen to the change in engine noise, if any. The cylinders which are misfiring will cause NO CHANGE in engine noise when the high pressure injection tubing nuts are loosened so that no fuel is injected into that cylinder. When the misfiring cylinders are located, the cause may be found as follows:

If fuel is not being discharged thru the loosened injection line, look for:

(a). Injection pump plunger stuck in upper position. REMEDY: Replace injection pump.

(b). Injection pump delivery valve stuck. REMEDY: Clean and wash thoroughly.

(c). Air in fuel system. REMEDY: Prime fuel system as described under "Adjustment and Operation."

If fuel is being discharged thru the injection tubing, look for:

(a). Broken or leaking injection tube or nozzle holder.

(b). Engine valve stuck or not closing from lack of adequate tappet clearance.

(c). Broken exhaust or inlet valve spring.

(2). If erratic engine firing cannot be located in any definite cylinder or cylinders the cause may be as follows:

(a). Air in fuel system. Check: Watch for air bubbles in sight glass of fuel injection pump. REMEDY: Prime fuel system.

(b). Dirty filter cartridges. REMEDY: Clean filters.

(c). Fuel injection nozzle sticking erratically. REMEDY: Clean and test nozzle.

(d). Injection pump delivery valve sticking erratically. REMEDY: Remove and clean.

(e). Engine valves sticking erratically. Check: The valve operating mechanism to see that it operates freely. If it is sticking or sluggish, it may be due to gum and carbon forming around the valve stems. REMEDY: Remove the cylinder head and valves. Clean the valves and guides. Obtain suitable lubricating and fuel oil.

c. Engine Knocks from Mechanical Causes.—

(1). Loose main or connecting rod bearings. REMEDY: Replace bearings, check crankshaft.

(2). Loose piston pins, worn bushings. REMEDY: Replace connecting rod bushing and check clearance.

(3). Worn pistons or liners. REMEDY: Check clearances, replace defective parts.

(4). Loose flywheel. REMEDY. Tighten flywheel to crankshaft capscrews.

(5). Valve tappet clearance too great.

(6). Broken valve spring.

d. Engine is Overheating.—

(1). Low cooling water. REMEDY: Refill cooling system.

(2). Cores of radiator plugged. REMEDY: Flush out radiator.

(3). Loose V-belts. REMEDY: Tighten V-belt tightener.

(4). Oil cooler plugged. REMEDY: Flush out oil cooler.

(5). Thermostat broken or sticking. REMEDY: Clean and replace if necessary.

e. Engine has Black Exhaust.—

(1). Engine may be overloaded.

(2). Air cleaners may be plugged. REMEDY: Flush cleaners, fill with new oil.

(3). Engine out of time. REMEDY: Time fuel injection pumps.

(4). Inadequate tappet clearance holding valves open continuously.

(5). Clogged filters. REMEDY: Clean filters and install new cartridge in cartridge type filter.

(6). Air leak in suction line of fuel transfer pump.

f. Engine Fires Regularly but Speed Changes When Load is On.—

(1). Clogged filters.

(2). Air in fuel system.

(3.) Governor control mechanism is binding. REMEDY: Adjust until it has a free working action.

(4). Loose electrical connections. REMEDY: Check all load, switchboard and generator connections and tighten if necessary.

(5). Governor is set incorrectly.

g. Low Lubricating Oil Pressure.—

(1). Oil gauge line stopped up or oil gauge is broken.

(2). Worn lubricating oil pump.

(3). Lubricating oil pump relief valve is stuck.

(4). Worn main bearings.

(5). Plugged metal edge type lubricating oil filter. REMEDY: Turn cleaning handle several times. If this handle cannot be turned by hand remove the filter cartridge and flush thoroughly.

(6). Worn valve rocker arm bushings.

(7). Worn camshaft bearings.

h. Engine Stops Suddenly.—

(1). Air-bound injection pumps is the cause of most sudden stops. The air gets into the system thru a leak in the suction side of the fuel transfer pump, and often accumulates in the filters until it is more or less full of air. When it goes into the injection pumps, "air binds" the pumps and the engine stops. REMEDY: Prime the engine and bleed the system of air.

(2). Safety control tripped.

(3). No fuel in tank. REMEDY: Fill the tank and prime the engine.

(4). Fuel filters plugged.

(5). Governor failure. REMEDY: Replace with new governor.

(6). Water in fuel.

(7). Fuel transfer pump not operating.

(8). Piston seizure due to lack of lubrication or engine over-heating. REMEDY: Remove piston and replace with a new one if badly scored. Clean the oil pan, lines and filters thoroughly and fill with new lubricating oil.

i. Exciter Brush Sparking.—

(1). Improper brush rigging setting. REMEDY: Examine notch in brush rigging and mark on bearing bracket. Loosen the bolt which holds the brush rigging rigid. Adjust the brush rigging to the notch and chisel mark. See Fig. 130, Page 133.

(2). Improper brush holder setting. REMEDY: Readjust the brush holders so brushes will ride the commutator correctly, and so clearance of 3/32″ is maintained between holders and commutator.

(3). Brushes stuck in holders. REMEDY: Remove spring tension and remove any obstruction. Move the brushes up and down in their holders.

(4). Broken or weak springs. REMEDY: Replace broken springs. Compare all springs with the tension of a good spring, replace the weak springs.

(5). Brushes not sanded sufficiently. REMEDY: Sand the exciter brushes as described on Fig. 131, Page 133.

(6). Insufficient brush pressure. REMEDY: Adjust spring tension one notch tighter.

(7). Worn, cracked or broken brushes. REMEDY: Replace brush assemblies as described on Page 133.

(8). High mica between commutator bars. REMEDY: Undercut the mica as described on Page 134.

(9). Dirty or oily commutator. REMEDY: Clean commutator. See Page 134.

(10). Rough commutator or commutator slightly out of round. REMEDY: Check by holding a small stick firmly on a brush or spring while the unit is running. Stone the commutator. See Page 134.

j. Generator Brush Sparking.—

(1). Insufficient brush pressure. REMEDY: Adjust spring tension one notch tighter.

(2). Brushes stuck in holders. REMEDY: Remove spring tension and remove any obstruction. Move the brushes up and down in their holders.

(3). Broken or weak springs. REMEDY: Replace broken springs. Compare all springs with the tension of a good spring, replace the weak springs.

(4). Worn, cracked or broken brushes. REMEDY: Replace brush assemblies as described on Page 133.

(5) Loose brush holder or brush holder stud. REMEDY: Tighten brush holder clamp bolt or brush holder jam nut.

(6). Dirty collector rings. REMEDY: Clean collector rings as described on Page 134.

(7). Rough collector rings. REMEDY: Check by holding a stick firmly on a brush or lever while the unit is running. Remove the rotor assembly and turn the collector rings in a lathe as described on Page 133.

k. Little or No Output Voltage.—

(1). Low speed. REMEDY: Check speed of engine and adjust governor if necessary.

(2). Loose connections.

(3). Incorrect connections. REMEDY: Check wiring diagrams and Instructions for Installations.

(4). Defective windings. REMEDY: Check resistances of windings with an ohmmeter, Wheatstone Bridge, or Kelvin Double Bridge.

(a). Remove exciter cover and end shield.

(b). Lift all brushes from collector rings and commutator.

(c). Check between lead clips (T_0) and either (T_1), (T_2) or (T_3). Reading should be approximately .025 ohms. Then check between any two of lead clips (T_1), (T_2) or (T_3). This reading should be aproximately .049 ohms. Replace generator stator assembly if test does not prove out.

(d). Check from one collector ring to another. The approximate reading should be about 13.9 ohms. If test does not prove out remove the rotor assembly from the stator and check between each coil to localize the defects. Replace the defective coil.

(e). Check between any first and the following 25th commutator bar. Reading should be approximately .985 ohms. If test does not prove out, replace the complete exciter armature.

(f). Check between (F_1) and the lead which is common to the other side of the exciter field, exciter brush rigging, and a collector ring, see Fig. 137, Page 137. The approximate reading should be 87 ohms. Continue to check between each exciter coil to localize the defect, and replace the defective coil.

(5). Failure of exciter voltage to build up.

(a). Check all wiring from the switchboard to the exciter.

(b). Lift all the brushes from their holders — engine not running.

(c). Connect the engine starting batteries to the exciter for a few seconds. Positive battery lead to exciter lead (F_1) and negative battery lead to opposite side of field.

(d). Replace brushes, end shield and cover.

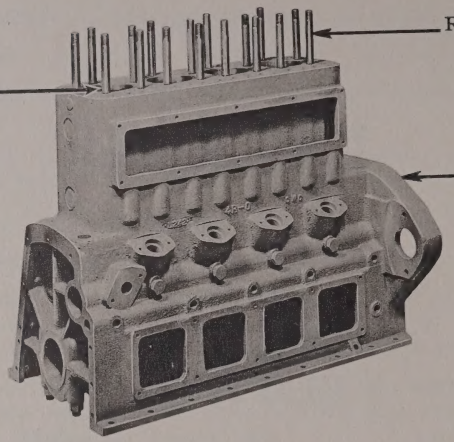
E APPENDIX

SECTION I

PARTS LIST
FOR
HILL 4-CYLINDER DIESEL ENGINE
MODEL 4R

PARTS LIST

Cylinder Block Assembly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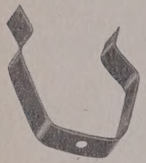
R-1670 (Cylinder Liner)
4R-O (Cylinder Block)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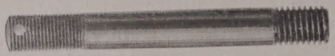
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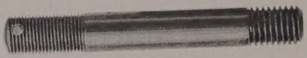
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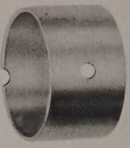
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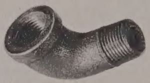
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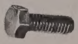
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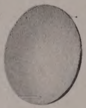
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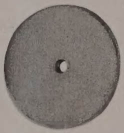
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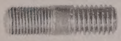
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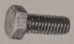
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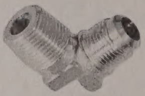
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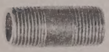
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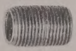
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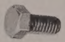
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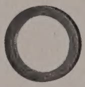
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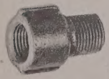
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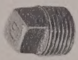
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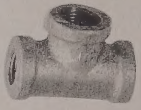
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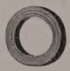
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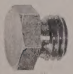
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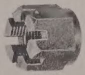
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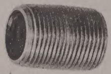
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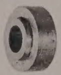
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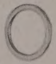
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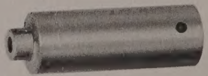
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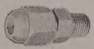
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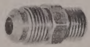
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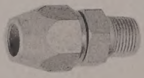
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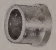
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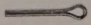
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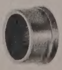
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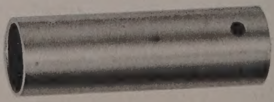
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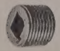
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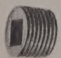
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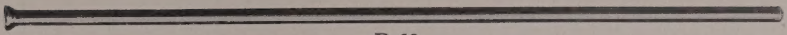
PARTS LIST

Cylinder Block Assembly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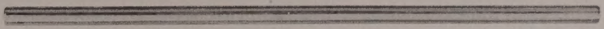
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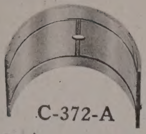
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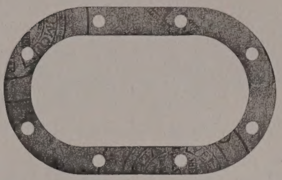
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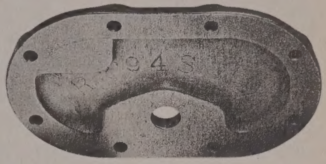
R-88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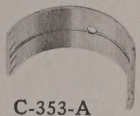
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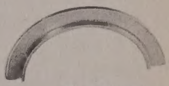
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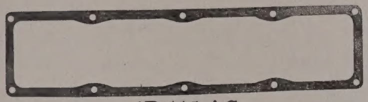
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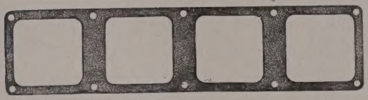
R-82-R

R-1854-S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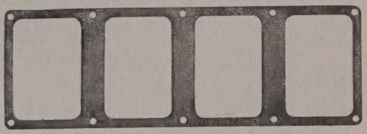
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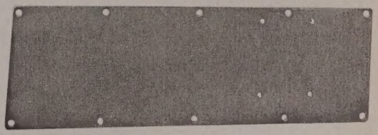
R-82-F

R-1854-A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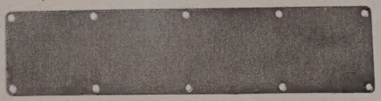
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PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-0	1	Cylinder Block	$289.22
R-8	17	Cylinder Head Studs	.36
R-60-C	6	Bearing Cap Stud, Center	.36
R-60-E	8	Bearing Cap Stud, End	.35
R-1105	14	Thru Bolt Bearing Cap Nut	.08
R-794-S	1	Clean Out Hole Plate	3.07
R-794-SG	1	Clean Out Hole Plate Gasket	.09
R-1670	4	Cylinder Liner	5.98
R-1704	4	Fuel Pump Priming Plug	.16
RF-1894	4	Fuel Pump Priming Plug Gasket	.02
R-1854-S	1	Oil Filter Cup	1.99
RC-3494	1	Straight Coupling, Male, ¼″ x ⅛″, Steel	.37
R-1854-A	1	Oil Filler Cup Cap	1.73
R-1854-B	1	Oil Filler Gasket	
R-1854-C	1	Oil Filler Cup Spring	
RC-3436	1	Rivet, Countersunk, 5/32″ x ½″, Copper	
116101	1	Copper Washer	

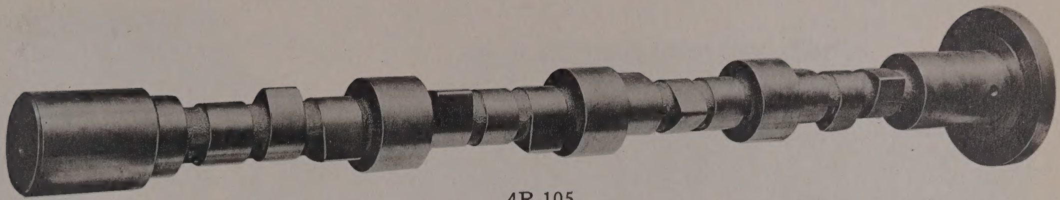
PARTS LIST

Cylinder Block Assembly

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
B-159-A	4	Front Engine Hangar Support Stud	$0.06
R-1927	4	Water Pump Stud	.09
100121	8	Capscrew, Hex. Head, U.S.S. 5/16″ x ¾″ (Clean Out Hole Plate)	.02
140802	2	Welsh Plug, 1/16″ x 1⅝″ dia., Brass	.05
103865	1	Pipe Plug, ⅛″ (Oil Return)	.03
103868	2	Pipe Plug, ½″, Cast Iron (Water Holes)	.03
121207	1	Close Nipple, ⅜″, Wrought Iron	.03
103873	3	Pipe Plug, Countersunk, ⅜″, Cast Iron (Main Oil Line Holes)	.05
RC-3344	1	Pipe Extension, ⅜″, Cast Iron	.08
103874	2	Pipe Plug, Countersunk, ½″, Cast Iron (Ends of Main Oil Line)	.06
109421	1	Pipe Nipple, ⅜″ x 1½″ (Breather Line Hole)	.04
144613	1	Pipe Nipple, Close, ¾″, Wr. Iron (Oil Filler Cup)	.05
RC-3497	1	Straight Coupling, Male, ½″ x ⅜″, Steel	.83
120063	1	Street Elbow, ⅜″ x 90° (Breather Line)	.12
RC-3862	1	Pipe Tee, ⅜″ x ¼″ x ⅜″, Mall. Iron (Breather Line)	.15
RC-3443	1	Tube Elbow, S.A.E., ½″, ½″ Pipe Thread Commonwealth A555, Brass (Water Outlet Hole)	1.06
118750	1	Tube Connector, S.A.E., ⅜″, ¼″ Pipe Thread Commonwealth No. 552, Brass (Breather Line)	.30
R-82-C	3	Camshaft Bearing, Center	.42
R-82-F	1	Camshaft Bearing, Front	.84
R-82-R	1	Camshaft Bearing, Rear	.64
C-353-A	6	Main Bearing Half, Center	.82
C-372-A	3	Main Bearing Half, End	1.68
R-372-R	1	Main Bearing Half, Rear	1.71
R-372-T	2	Thrust Collar Half, Rear	1.30
R-88	4	Cylinder Head Gasket	.07
R-1693	1	Vertical Oil Tube	.59
R-1693-A	1	Vertical Oil Tube Collar	.18
R-1699	8	Push Rod Cylinder Bushing	.08
R-1697	8	Circulating Water Bushing	.10
R-1737	2	Cylinder Head Dowel	.03
R-1698	9	Circulating Water Rubber Grommet	.07
R-1700	8	Push Rod Rubber Grommet	.09
R-30	8	Valve Tappet	1.29
R-62	8	Push Rod	.27
R-1692	4	Fuel Pump Tappet	1.07
4PR-57-N	1	Hand Hole Plate, Large	2.16
4R-115-G	1	Hand Hole Plate Gasket, Large	.11
4R-115-A	1	Hand Hole Plate, Small	1.36
4R-115-AG	1	Hand Hole Plate Gasket, Small	.08
4R-115-A	1	Push Rod Cover Plate	1.36
4R-115-AG	1	Push Rod Cover Plate Gasket	.08
106324	26	Capscrew, Hex. Head, U.S.S. 5/16″ x ⅝″ (Hand Hole and Push Rod Cover Plates)	.02
106325	2	Capscrew, Hex. Head, U.S.S. 5/16″ x ⅞″	.02
103320	28	Lock Washer, Medium, 5/16″	.01
103385	14	Cotter Pin, ⅛″ x 1″ (Bearing Cap Nut)	.01

PARTS LIST

Camshaft Assembly



4R-105

100027-A

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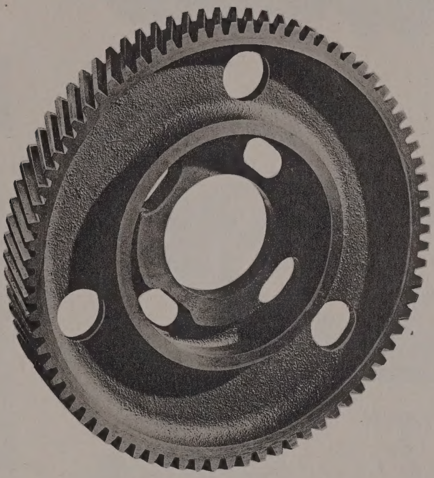

R-6

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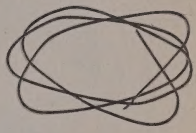
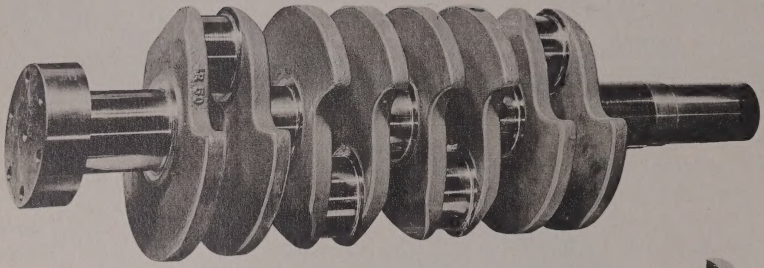


RC-3246

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
R-6	1	Camshaft Gear	$14.11
4R-105	1	Camshaft	15.89
100027-A	4	Capscrew, Hex. Head, Drilled S.A.E. 3/8″ x 1¼″	.04
106263	4	Flat Washer, 3/8″	.01
103321	4	Lock Washer, Medium, 3/8″	.01
RC-3246	1	Wire, Black Annealed, No. 18, 12″	.01

PARTS LIST

Crankshaft Assembly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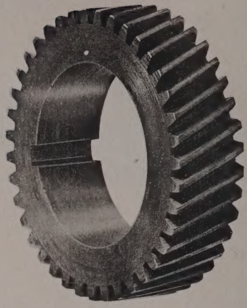
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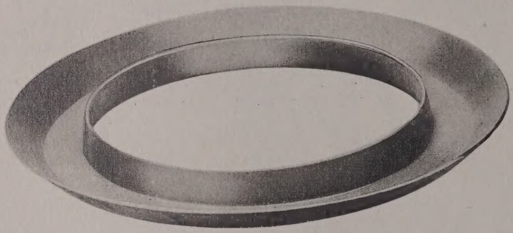
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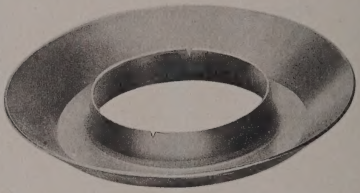
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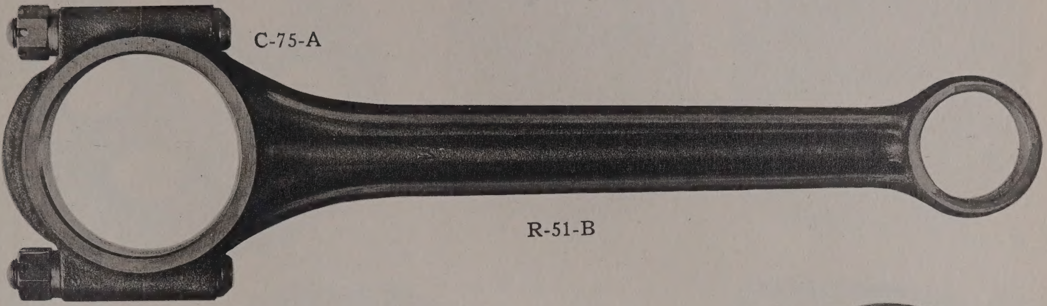
PART NUMBER	QUANTITY	PART NAME	PRICE EACH
R-42	1	Pinion Gear	$ 17.79
4R-50	1	Crankshaft	107.19
117979	1	Woodruff Key, No. C	.04
R-1276-F	1	Oil Slinger, Front	.16
R-1276-R	1	Oil Slinger, Rear	.20

PARTS LIST

Connecting Rod and Piston Assembly



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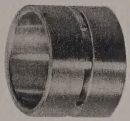

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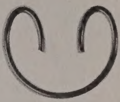

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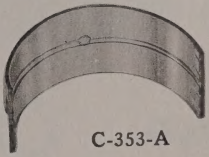
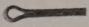


C-353-A

R-3-B



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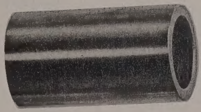

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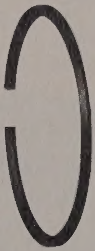

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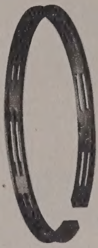
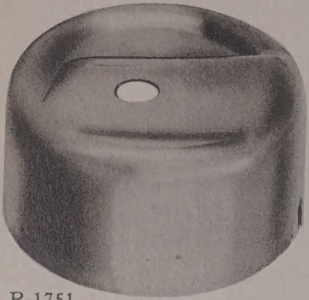


R-16-A

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
R-3-B	4	Piston	$ 3.00
R-46	4	Piston Pin	.72
R-1772	8	Piston Pin Lock Ring	.03
R-45	4	Connecting Rod Bushing	.64
R-51-B	4	Connecting Rod	14.77
C-75-A	8	Connecting Rod Bolt	.09
C-353-A	8	Connecting Rod Bearing Half	.82
R-1106	8	Connecting Rod Bolt Nut	.05
R-16	12	Compression Ring, 3½″ x ⅛″	.06
R-16-A	8	Oil Ring, 3½″ x ¼″	.11
103384	8	Cotter Pin, ⅛″ x ¾″	.01

PARTS LIST

Lubricating Oil Pump Assembly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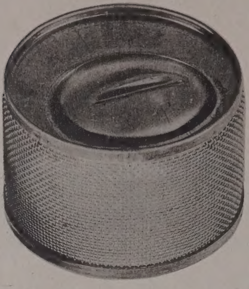
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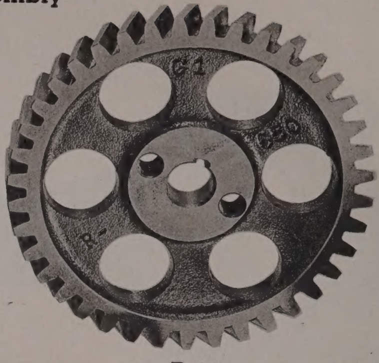
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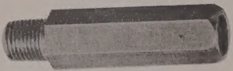
103321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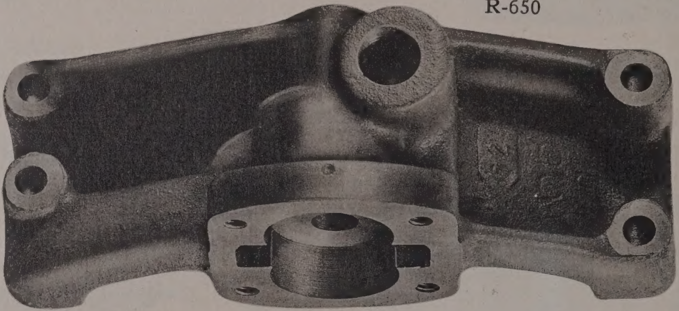

2R-655

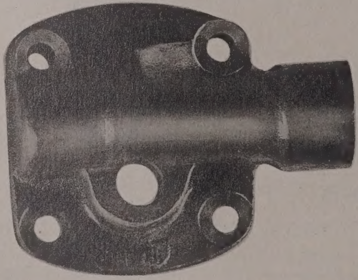
100122-A

103323

R-992

R-1748

R-990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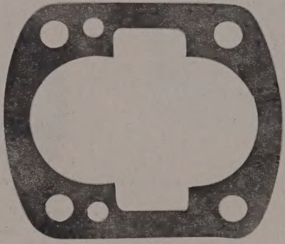
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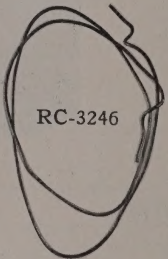
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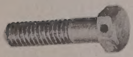
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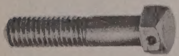
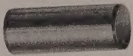

100137-A

106749

103320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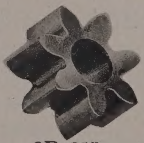
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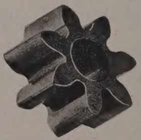
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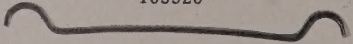
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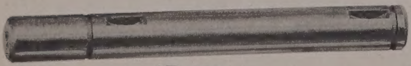
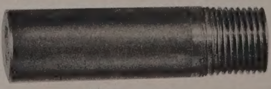

2R-659

R-991-A


4PR-57-S

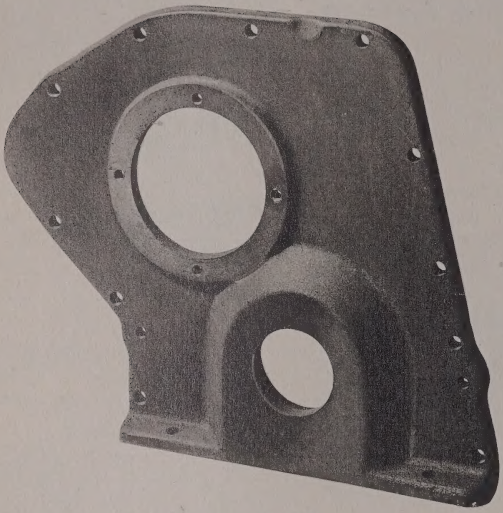
PARTS LIST

Lubricating Oil Pump Assembly

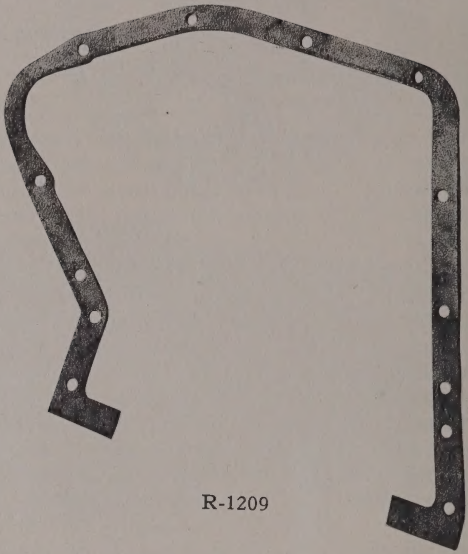
PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4PR-57-T	1	Lubricating Oil Pump Complete	$32.60
R-650	1	Lubricating Oil Pump Drive Gear	3.53
2R-655	1	Lubricating Oil Pump Body	17.33
R-656	1	Lubricating Oil Pump Body Cover	2.31
2R-657	1	Lubricating Oil Pump Drive Gear	.51
2R-658	1	Lubricating Oil Pump Driven Gear	.51
2R-659	1	Lubricating Oil Pump Drive Shaft	1.26
2R-660	1	Lubricating Oil Pump Stub Shaft	.07
R-990	1	Lubricating Oil Pump Relief Valve	.27
R-991-A	1	Lubricating Oil Pump Relief Valve Spring	.04
R-992	1	Lubricating Oil Pump Relief Valve Plug	.11
R-1026	2	Lubricating Oil Pump Body Gasket	.01
4PR-57-S	1	Lubricating Oil Pump Suction Fitting	.50
R-1748	2	Lubricating Oil Pump Drive Shaft Snap Ring	.03
R-1751	1	Lubricating Oil Pump Cleaner Housing	.23
R-1752	1	Lubricating Oil Pump Cleaner Screen	.29
R-1753	1	Lubricating Oil Pump Suction Fitting	.12
R-1754	1	Lubricating Oil Pump Cleaner Spring Clip	.29
100122-A	2	Capscrew, Hex. Head, drilled, U.S.S., 5/16″ x 1″	.03
100123-A	2	Capscrew, Hex. Head, drilled, U.S.S., 5/16″ x 1¼″	.03
103320	4	Lock Washer, Medium, 5/16″	.01
103323	1	Lock Washer, Medium, ½″	.01
106749	2	Woodruff Key, No. 3	.01
RC-3246	2	Wire, Black Annealed, No. 18, 12″	.01
100137-A	4	Capscrew, Hex. Head, drilled, U.S.S., ⅜″ x 1¾″	.04
103321	4	Lock Washer, Medium, ⅜″	.01

PARTS LIST

Gear Case Cover Assembly

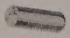


R-781



R-1209

100134



R-1749

C-159

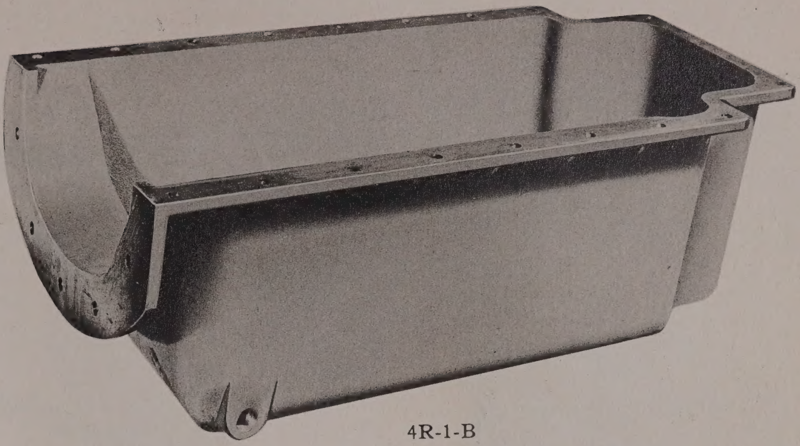
103321

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
R-781	1	Gear Case Cover	$4.87
R-1209	1	Gear Case Cover Gasket	.10
R-1749	2	Gear Case Dowel	.03
100134	8	Capscrew, Hex. Head, U.S.S., ⅜″ x 1″	.02
C-159	1	Stud, Generator Belt Tightener	.05
103321	9	Lock Washer, Medium, ⅜″	.01

PARTS LIST

Oil Pan Assembly

100028

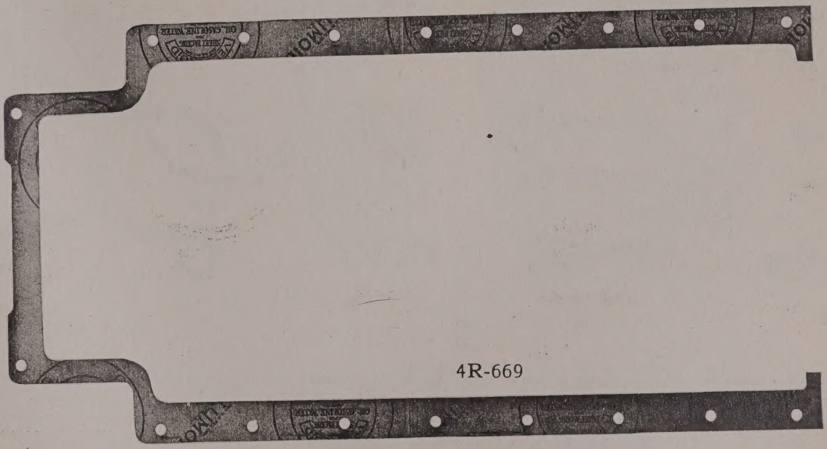


4R-1-B

174848

100027

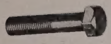
177578



4R-669

103868

103321

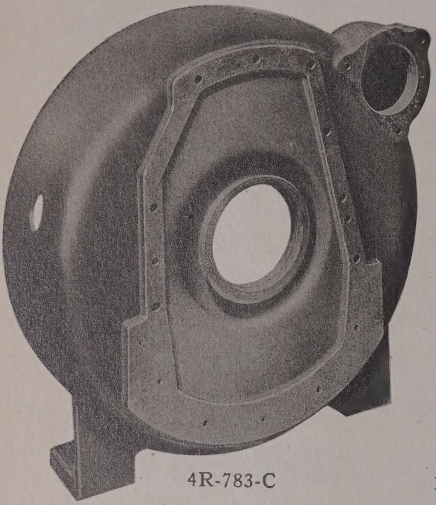


100029

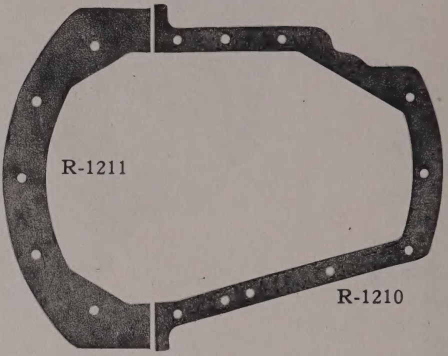
PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-1-B	1	Oil Pan	$29.09
4R-669	1	Oil Pan Gasket	.19
100027	2	Capscrew, Hex. Head, S.A.E., ⅜" x 1¼" (Gear Case Cover)	.02
100028	12	Capscrew, Hex. Head, S.A.E., ⅜" x 1½"	.02
100029	4	Capscrew, Hex. Head, S.A.E., ⅜" x 1¾"	.02
174848	15	Nut, Hex., S.A.E., ⅜"	.01
177578	3	Lock Nut, Hex., S.A.E., ⅜"	.01
103321	18	Lock Washer, Medium, ⅜"	.01
103868	1	Pipe Plug, ½", Cast Iron	.03

PARTS LIST

Flywheel Housing Assembly

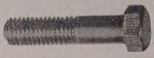


4R-783-C



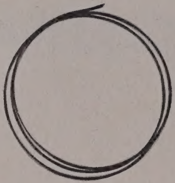
106972

113955



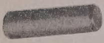
100137

103319

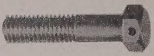


RC-3248

R-1298



R-1750



100137-A

100135

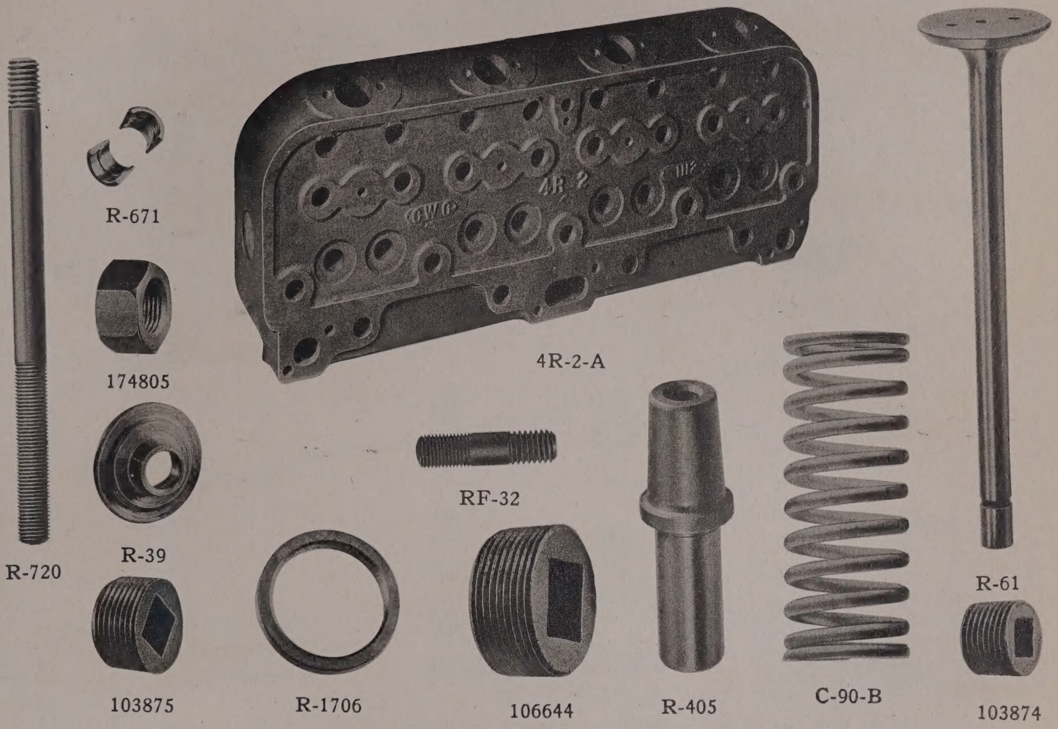
103321

R-98

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-783-C	1	Flywheel Housing, No. 1 S.A.E.	$39.94
R-98	1	Flywheel Timing Pointer	1.62
R-1298	1	Timing Cover Plate	.02
106972	2	Capscrew, Hex. Head, U.S.S., ¼″ x ½″	.01
113955	2	Stove Bolt, Round Head, ¼″ x ½″	.01
103319	4	Lock Washer, Medium, ¼″	.01
R-1210	1	Flywheel Housing Gasket, Upper	.10
R-1211	1	Flywheel Housing Gasket, Lower	.08
R-1750	2	Flywheel Housing Dowel	.03
100135	2	Capscrew, Hex. Head, U.S.S., ⅜″ x 1¼″	.02
100137	3	Capscrew, Hex. Head, U.S.S., ⅜″ x 1¾″	.02
100137-A	8	Capscrew, Hex. Head, Drilled, U.S.S., ⅜″ x 1¾″	.04
103321	13	Lock Washer, Medium, ⅜″	.01
RC-3248	1	Wire, Black Annealed, No. 18, 24″	.01

PARTS LIST

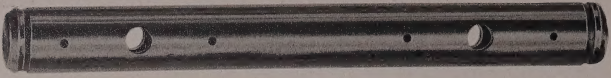
Cylinder Head Assembly


R-671
174805
4R-2-A
R-39
RF-32
R-720
R-61
103875
R-1706
106644
R-405
C-90-B
103874

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-2-A	1	Cylinder Head	$92.32
RF-32	8	Fuel Injection Nozzle Stud	.06
R-39	8	Valve Spring Cap	.58
R-61	8	Inlet and Exhaust Valve	.85
C-90-B	8	Valve Spring	.14
R-405	8	Valve Stem Guide	.14
R-671	8	Valve Spring Retainer	.02
R-1706	8	Valve Seat Insert	.48
103874	4	Pipe Plug, Countersunk, ½″	.06
103875	4	Pipe Plug, Countersunk, ¾″	.07
106644	2	Pipe Plug, Countersunk, 1¼″	.13
R-720	4	Valve Cover Stud	.10
174805	17	Nut, Hex., S.A.E., ⅝″ (Cylinder Head Stud)	.04

PARTS LIST

Valve Lever and Bracket Assembly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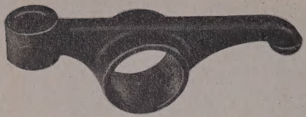
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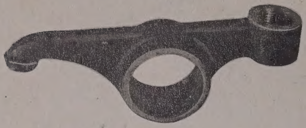
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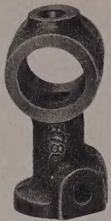
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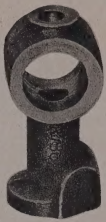
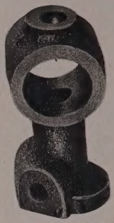

R-786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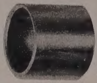
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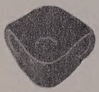
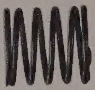

4R-1695

C-454-A

R-1664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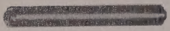
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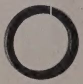
174848

103320

103891

C-454

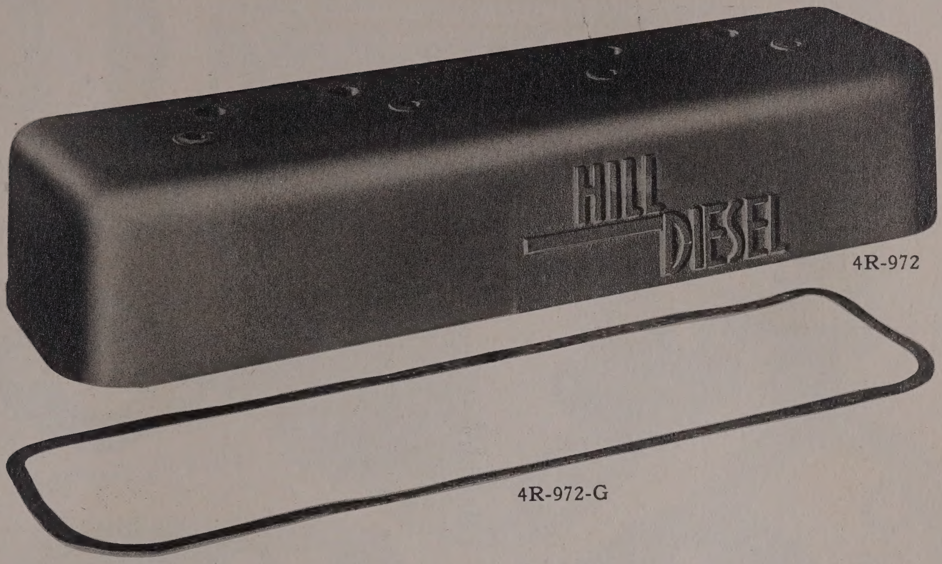
100123


R-1771

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
R-430-R	4	Valve Lever, Right	$6.89
R-430-L	4	Valve Lever, Left	6.89
C-454	8	Valve Lever Adjusting Screw	.18
C-454-A	8	Push Rod Adjusting Nut	.05
R-786	2	Valve Lever Bracket	3.42
R-786-L	1	Valve Lever Bracket, Left	4.07
R-786-R	1	Valve Lever Bracket, Right	4.07
2R-973	2	Valve Rocker Arm Shaft	2.32
C-974	4	Valve Lever Shaft Spring	.02
R-1771	4	Rocker Arm Snap Ring	.02
R-1694	2	Horizontal Oil Tube	.37
4R-1695	1	Oil Tube Connection	.67
C-1471	8	Valve Lever Bushing	.15
103891	4	Welsh Plug, ⅝″ dia., Steel	.01
R-1664	8	Valve Stem Cap	.04
100123	1	Capscrew, Hex. Head, U.S.S., 5/16″ x 1¼″	.02
174848	4	Nut, Hex., S.A.E., ⅜″	.01
103320	1	Lock Washer, Medium, 5/16″	.01

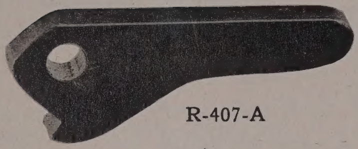
PARTS LIST

Valve Cover Assembly

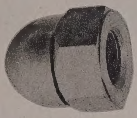


4R-972

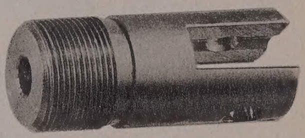
4R-972-G



R-407-A



131486



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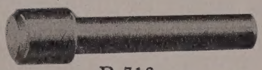
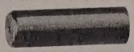
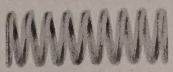


R-713



R-409

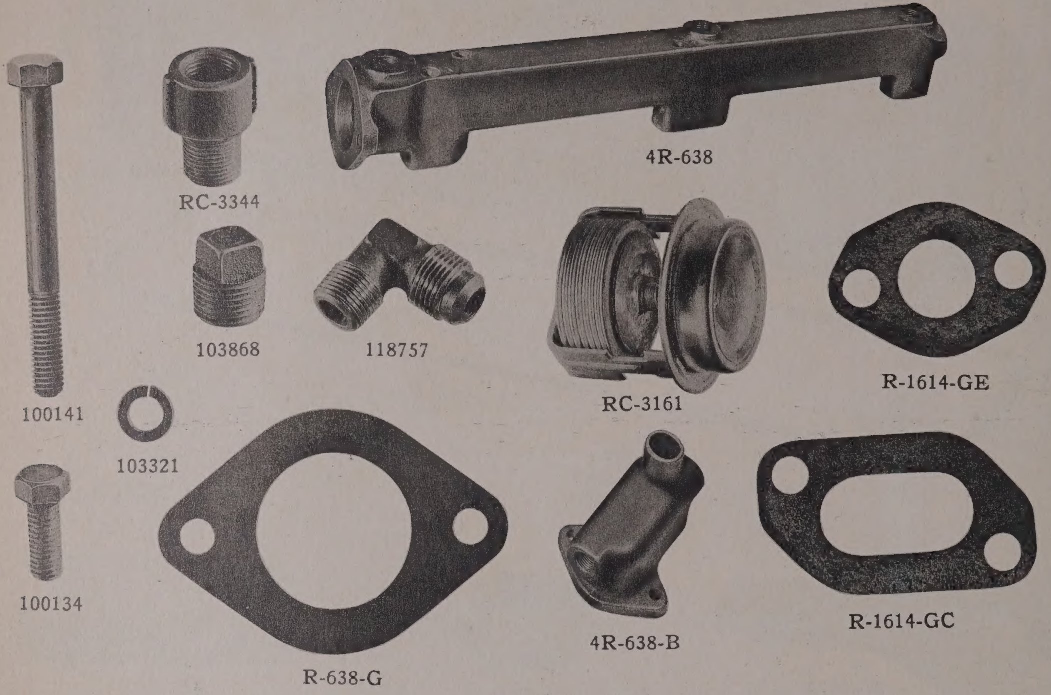


R-408

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-972	1	Valve Cover	$10.89
4R-972-G	1	Valve Cover Gasket	.10
131486	4	Nut, Acorn, S.A.E., ⅜″, Steel	.04
LR-31	4	Compression Release Assembly:	3.21
R-713	4	Compression Release Lever pin	.07
R-1702	4	Compression Release Pin Housing	.85
R-408	4	Compression Release Pin Spring	.02
R-409	4	Compression Release Lever Cross Pin	.03
R-407-A	4	Compression Release Lever	.07

PARTS LIST

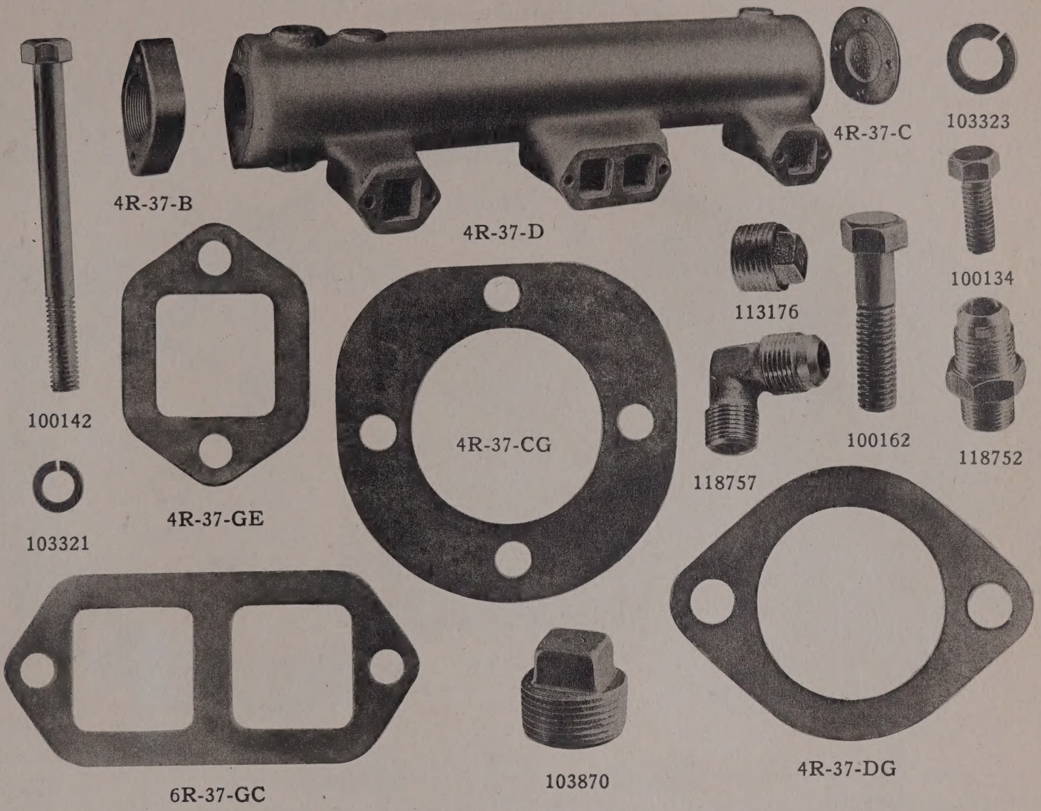
Water Outlet Manifold Assembly


4R-638
RC-3344
103868
118757
RC-3161
R-1614-GE
100141
103321
100134
R-638-G
4R-638-B
R-1614-GC

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-638	1	Water Outlet Manifold	$12.99
4R-638-B	1	Water Outlet Gland (Thermostat Housing)	4.47
R-638-G	1	Water Outlet Gland Gasket	.02
RC-3161	1	Thermostat, Fulton, V-147	1.08
100134	2	Capscrew, Hex. Head, U.S.S., ⅜″ x 1″	.02
103321	8	Lock Washer, Medium, ⅜″	.01
100141	6	Capscrew, Hex. Head, U.S.S., ⅜″ x 3½″	.04
103868	1	Pipe Plug, ½″, Cast Iron	.03
RC-3344	1	Pipe Extension, ⅜″ x ⅜″, Cast Iron	.09
118757	1	Tube Elbow, S.A.E., ½″, ⅜″ Pipe Thread, Commonwealth, No. 555, Brass	.64
R-1614-GC	1	Water Outlet Manifold Gland Gasket, Center	.02
R-1614-GE	1	Water Outlet Manifold Gland Gasket, End	.02

PARTS LIST

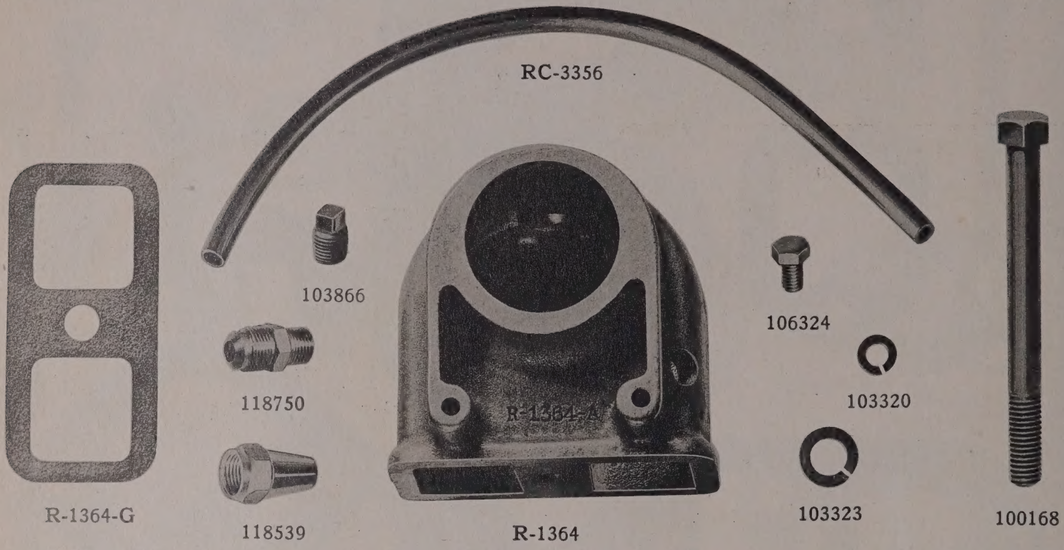
Exhaust Manifold Assembly


4R-37-B
4R-37-D
4R-37-C
103323
100134
113176
100142
4R-37-GE
4R-37-CG
100162
118752
118757
103321
6R-37-GC
103870
4R-37-DG

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-37-D	1	Exhaust Manifold	$36.76
4R-37-B	1	Exhaust Pipe Gland	2.13
4R-37-C	1	Exhaust Manifold End Plate	1.69
4R-37-CG	1	Exhaust Manifold End Plate Gasket	.06
4R-37-DG	1	Exhaust Pipe Gland Gasket	.05
6R-37-GC	1	Exhaust Manifold Gasket, Center	.06
4R-37-GE	2	Exhaust Manifold Gasket, End	.02
100142	6	Capscrew, Hex. Head, U.S.S., ⅜″ x 4″	.05
100134	4	Capscrew, Hex. Head, U.S.S., ⅜″ x 1″ (End Plate)	.02
100162	2	Capscrew, Hex. Head, U.S.S., ½″ x 2″ (Pipe Gland)	.05
103321	10	Lock Washer, Medium, ⅜″	.01
103323	2	Lock Washer, Medium, ½″	.01
113176	4	Pipe Plug, ½″, Brass	.19
103870	1	Pipe Plug, 1″, Cast Iron	.06
118757	1	Tube Elbow, S.A.E., ½″, ⅜″ Pipe Thread, Commonwealth No. 555, Brass	.64
118752	1	Tube Connector, S.A.E., ½″, ⅜″ Pipe Thread, Commonwealth No. 552, Brass	.41

PARTS LIST

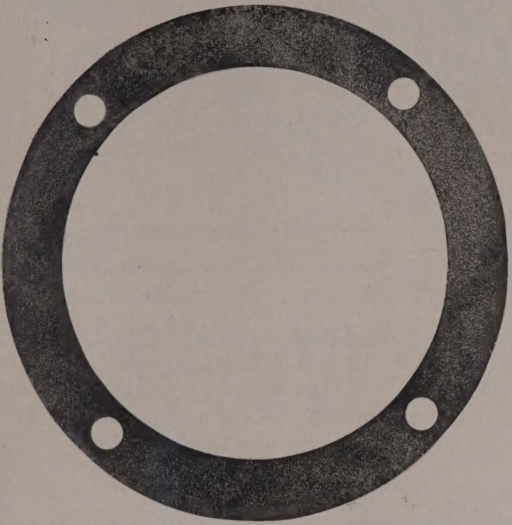
Air Cleaner Assembly


RC-3356
103866
106324
118750
103320
R-1364-A
R-1364-G
118539
R-1364
103323
100168

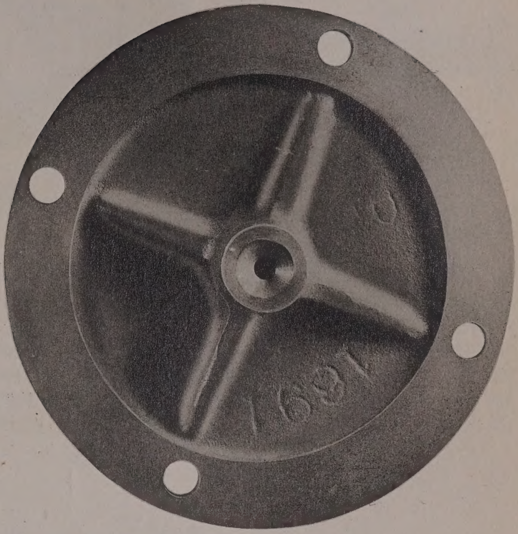
PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3212	2	Air Cleaner, United TO-45-11700	$2.70
See Pg. 194 for replacement parts.			
R-1364	2	Air Cleaner Gland	1.71
106324	4	Capscrew, Hex. Head, U.S.S., 5/16″ x ⅝″	.02
103320	4	Lock Washer, Medium, 5/16″	.01
103866	1	Pipe Plug, ¼″, Cast Iron	.01
118750	1	Tube Connector, S.A.E., ⅜″, ¼″ Pipe Thread, Commonwealth No. 552, Brass	.30
R-1364-G	2	Air Cleaner Gland Gasket	.03
100168	2	Capscrew, Hex. Head, U.S.S., ½″ x 5″	.11
103323	2	Lock Washer, Medium, ½″	.01
RC-3356	1	Tubing, ⅜″ O.D. x .035″ Wall x 14″ Long, Copper (Air Cleaner Breather Line)	1.76
118539	2	Tube Nut, S.A.E., ⅜″, Commonwealth No. 551, Brass	.26

PARTS LIST

Camshaft Thrust Plate Assembly



R-1691-G



R-1691

100134

103321

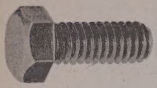
100133

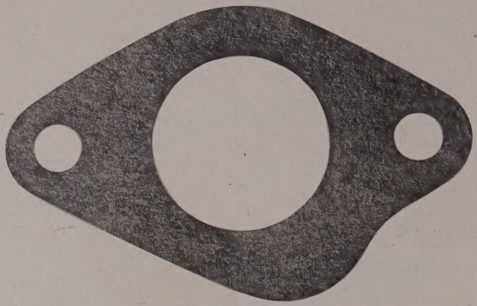
PART NUMBER	QUANTITY	PART NAME	PRICE EACH
R-1691	1	Camshaft Thrust Plate	$3.56
R-1691-G	1	Camshaft Thrust Plate Gasket	.04
100133	1	Capscrew, Hex. Head, U.S.S., ⅜" x ¾"	.02
100134	3	Capscrew, Hex. Head, U.S.S., ⅜" x 1"	.02
103321	4	Lock Washer, Medium, ⅜"	.01

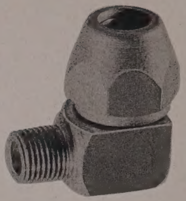
PARTS LIST

Fuel Transfer Pump Assembly

103320

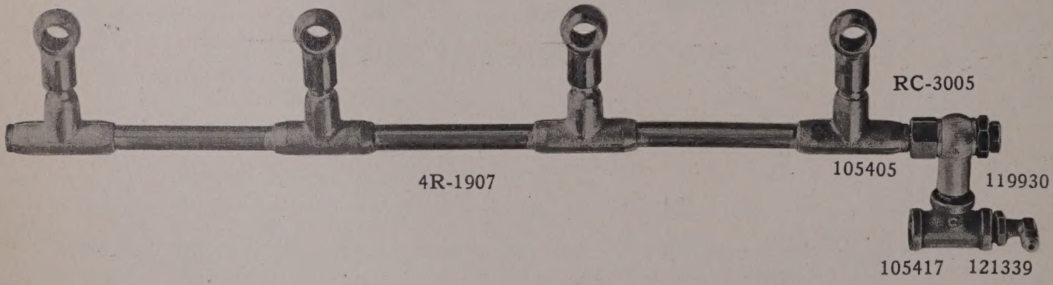

100121


B-1608


RC-3491

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3136	1	Fuel Transfer Pump, AC, No. AC-1523378	$10.00
See Pg. 195 for replacement parts.			
RC-3491	2	Tube Elbow, 90°, Male, 5/16″ x ⅛″ Pipe Thread, Steel	.70
B-1608	1	Fuel Transfer Pump Gasket	.04
100121	2	Capscrew, Hex. Head, U.S.S., 5/16 x ¾″	.02
103320	2	Lock Washer, Medium, 5/16″	.01

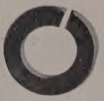
Fuel Injection Header Assembly



PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-1907	1	Fuel Injection Header	$13.56
RC-3005	1	Check Valve Assembly, Bosch PVE-1A-2Z	3.70
See Pg. 198 for replacement parts.			
105405	1	Pipe Nipple, Close, ¼″, Cast Iron	.05
119930	1	Pipe Bushing, ¼″ x ⅛″, Malleable Iron	.06
105417	1	Pipe Tee, ¼″, Malleable Iron	.13
121339	1	Tube Elbow, S.A.E., 3/16, ⅛″ Pipe Thread, Commonwealth No. 555, Brass	.29

PARTS LIST

Fuel Injection Pump Assembly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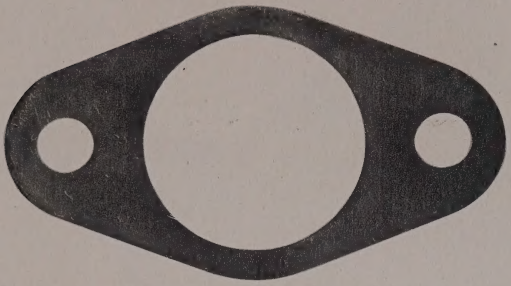
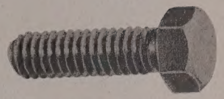

R-1729-G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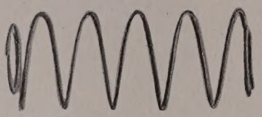

4RF-200

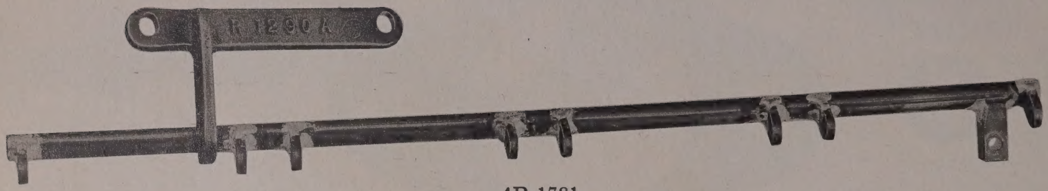
R-1745-A

140867

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3001	4	Fuel Injection Pump, Bosch APF-1A-80A-S54	$44.10
See Pg. 196 for replacement parts.			
4RF-200	4	Fuel Pump Control Rod Spring	.04
R-1745-A	4	Fuel Pump Collar	.22
140867	4	Set Screw, Allen, No. 10 x 24 x 3/16″	.06
R-1729-G	12 (Ave.)	Fuel Pump Gasket	.03
100122	8	Capscrew, Hex. Head, U.S.S., 5/16″ x 1″	.05
103320	8	Lock Washer, Medium, 5/16″	.01

PARTS LIST

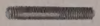
Governor Control Rack Assembly


4R-1781

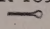
174844

100002

103319


R-1887

R-1891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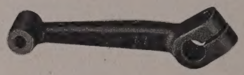
4R-1888

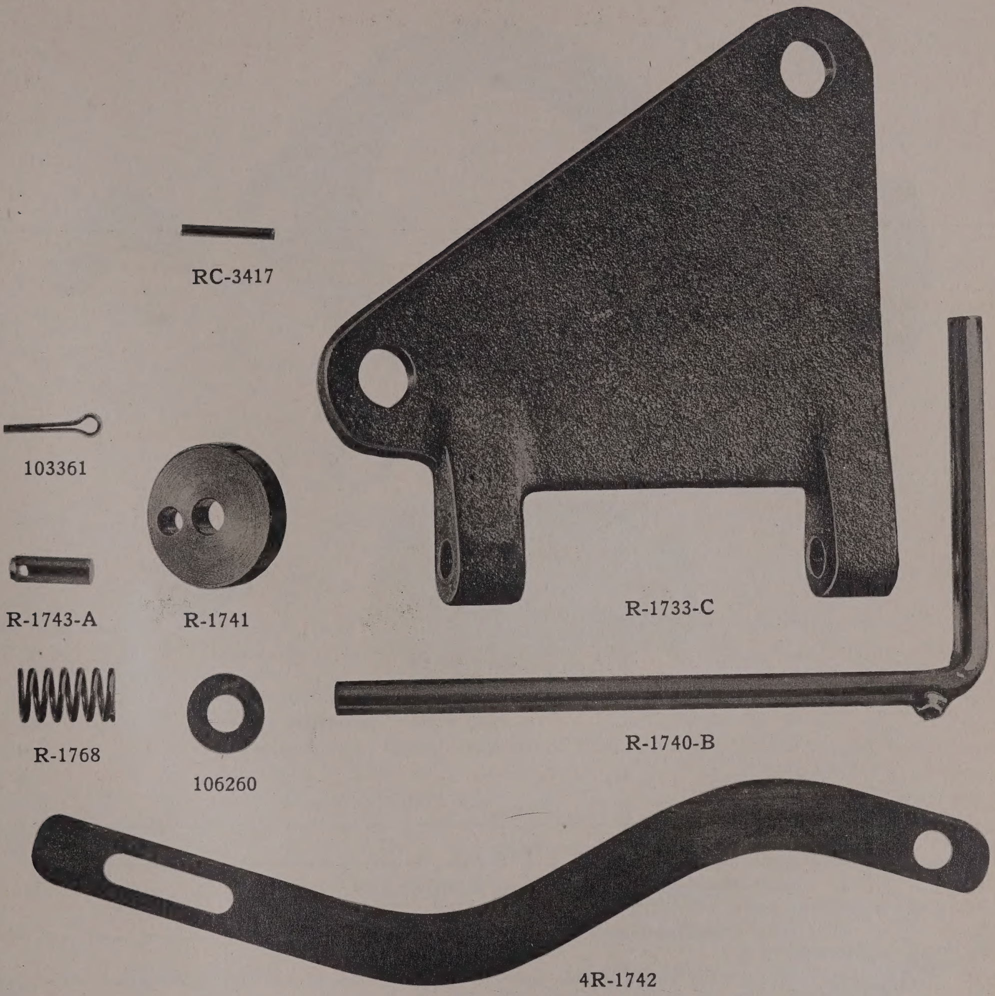
106274


R-978-A

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-1781	1	Governor Rack Including Bracket and Lugs	$6.07
R-1887	1	Overload Stop Stud	.12
4R-1888	1	Overload Stop Washer	.07
106274	8	Capscrew, Hex. Head, S.A.E., ¼″ x ⅝″	.01
174844	10	Nut, Hex., S.A.E., ¼″	.01
R-1891	1	Governor Lever Pin	.12
R-978-A	1	Governor Lever	1.26
100002	1	Capscrew, Hex. Head, S.A.E., ¼″ x 1″	.01
103319	1	Lock Washer, Medium, ¼″	.01
103361	2	Cotter Pin, 1/16″ x ½″	.01

PARTS LIST

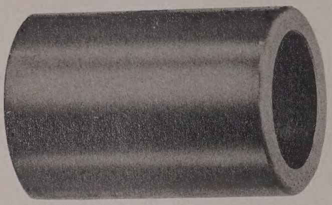
Engine Stop Assembly


RC-3417
103361
R-1743-A
R-1741
R-1733-C
R-1768
106260
R-1740-B
4R-1742

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
R-1733-C	1	Stop Lever Bracket	$3.95
R-1740-B	1	Engine Stop Lever	.16
R-1741	1	Engine Stop Disc	.36
R-1743-A	1	Engine Stop Disc Pin	.05
R-1768	1	Engine Stop Lever Spring	.02
4R-1742	1	Engine Stop Governor Connection	.45
RC-3417	1	Stop Lever Pin, 3/32″ x ⅝″	.05
103361	1	Cotter Pin, 1/16″ x ½″	.01
106260	1	Flat Washer, 3/16″	.01

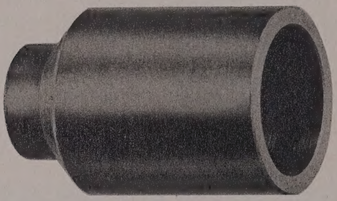
PARTS LIST

Fuel Injection Nozzle Assembly



R-1712

121339



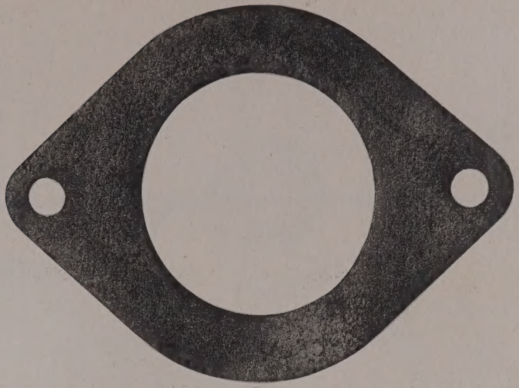
RF-30

174848

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3003	4	Fuel Injection Nozzle, Bosch, ADN-4S-D24	$11.00
See Pg. 197 for replacement parts.			
RC-3002	4	Fuel Injection Nozzle Holder, Bosch, AKB-35SD-173	13.60
See Pg. 197 for replacement parts.			
R-1712	4	Nozzle Holder Adapter	.69
RF-30	4	Pre-Combustion Chamber	.61
174848	8	Nut, Hex., S.A.E., ⅜"	.01
121339	4	Tube Elbow, S.A.E., 3/16", ⅛" Pipe Thread, Commonwealth No. 555, Brass	.29

PARTS LIST

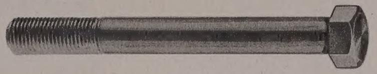
Governor Assembly



R-1609

174848

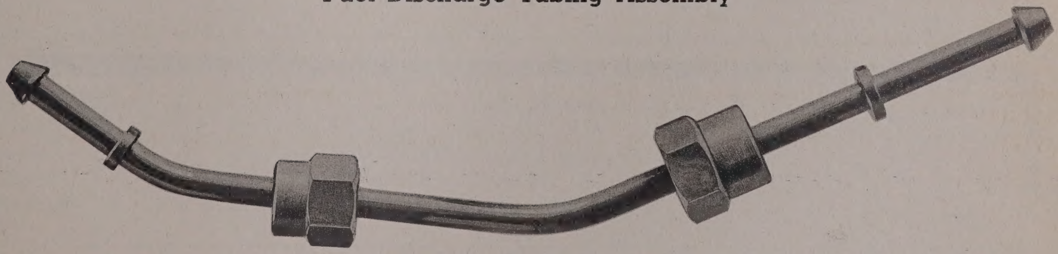
103321



100033

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3145	1	Governor, Pierce, GC-438	$43.00
See Pg. 199 for replacement parts.			
R-798	1	Governor Gear	2.34
R-1609	1	Pierce Governor Flange Gasket	.02
100033	2	Capscrew, Hex. Head, S.A.E., ⅜" x 3½"	.04
174848	2	Nut, Hex., S.A.E., ⅜"	.01
103321	2	Lock Washer, Medium, ⅜"	.01

Fuel Discharge Tubing Assembly

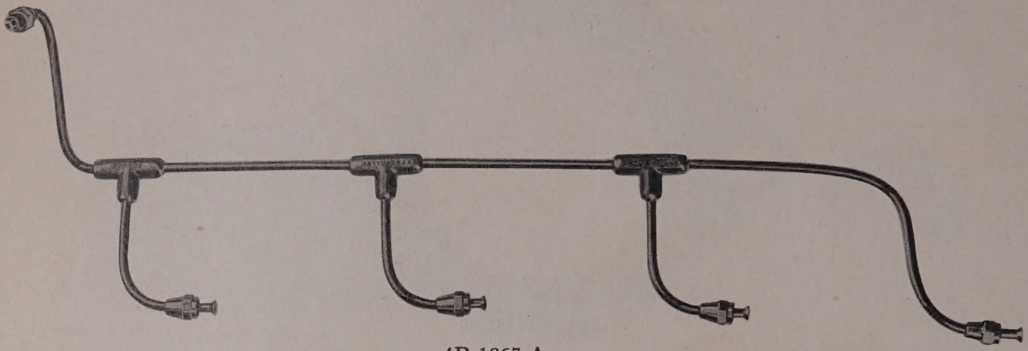


RF-177-B

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RF-177-B	4	Fuel Discharge Tubing, Completely Assembled	$ 3.84

PARTS LIST

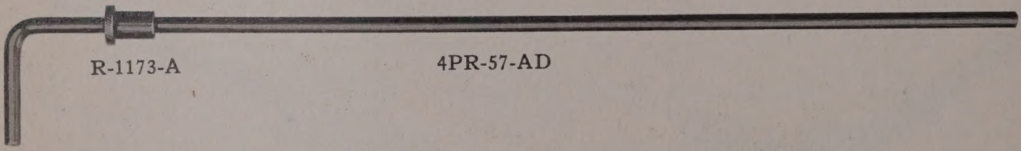
Fuel Overflow Tubing Assembly



4R-1867-A

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-1867-A	1	Fuel Overflow Tubing, Completely Assembled	$ 7.32

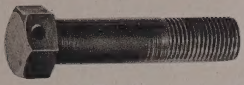
Oil Gauge Rod Assembly



PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4PR-57-AD	1	Oil Gauge Rod	$ 0.79
R-1173-A	1	Oil Gauge Rod Bushing	

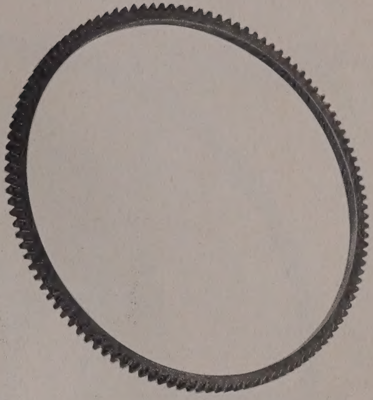
PARTS LIST

Flywheel Assembly

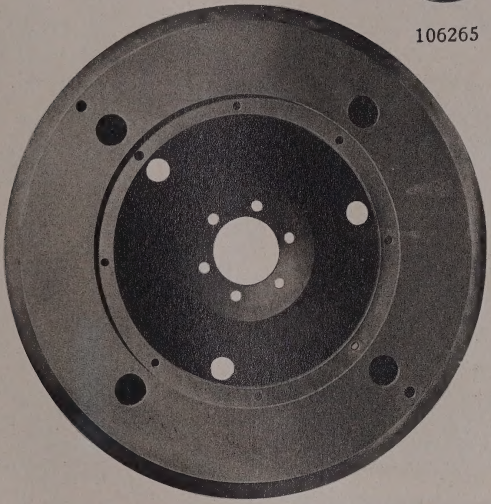


R-832

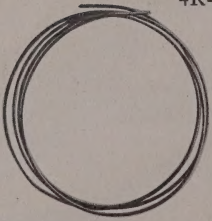
106265



4R-948-A



4PR-57-E

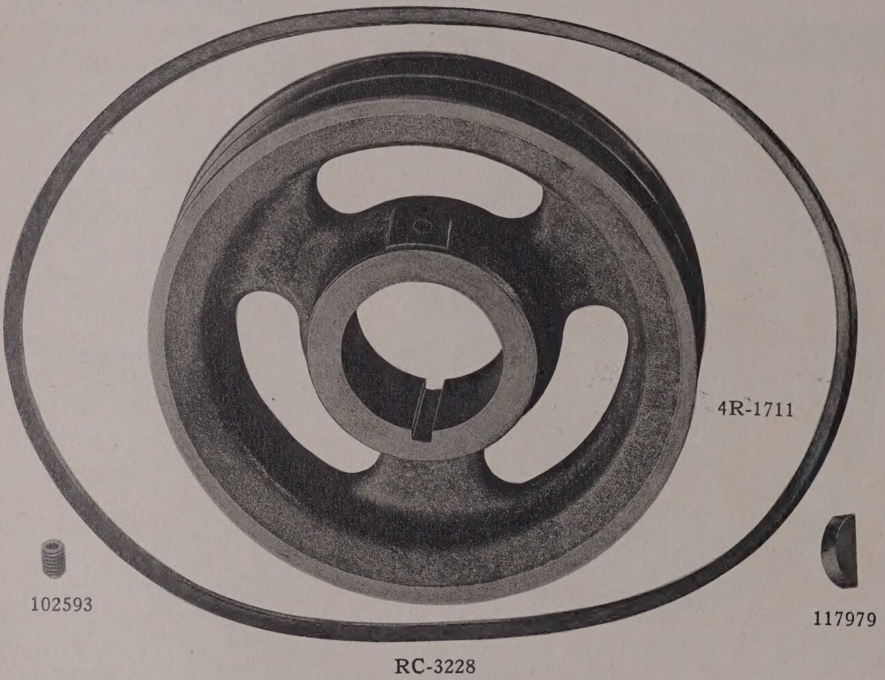


RC-3247

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4PR-57-E	1	Flywheel	$62.74
4R-948-A	1	Flywheel Ring Gear	10.03
R-832	6	Flywheel Bolt, Drilled	.26
106265	6	Flat Washer, ½"	.01
RC-3247	1	Wire, Black Annealed, No. 18, 18"	.01

PARTS LIST

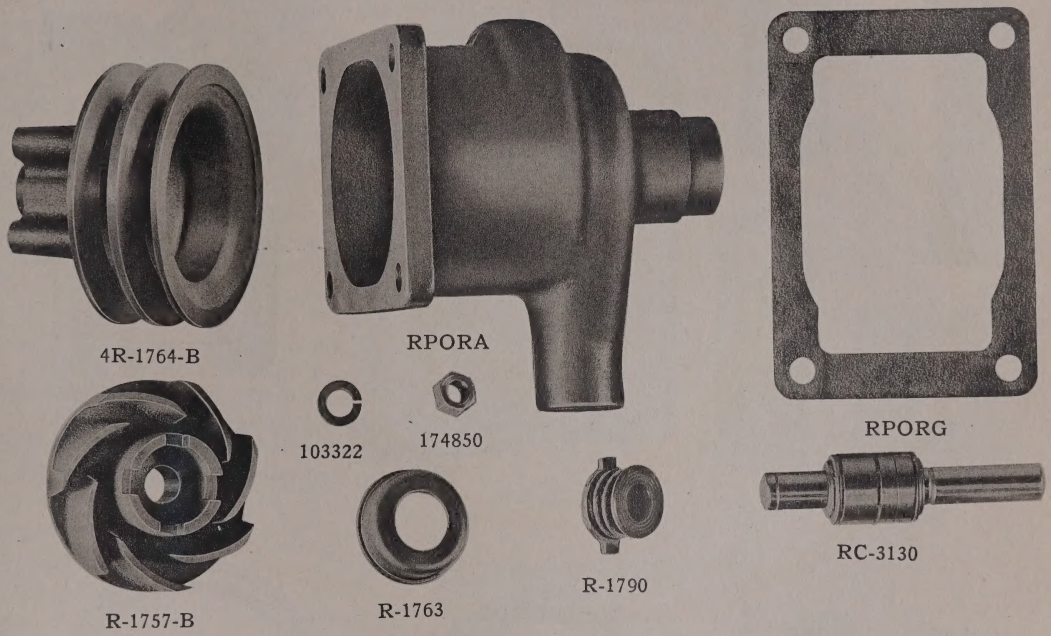
Crankshaft Sheave Assembly


4R-1711
102593
117979
RC-3228

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4R-1711	1	Crankshaft Sheave	$6.60
RC-3228	2	V-Belt, Dayton, 2MO-56	.98
102593	1	Set Screw, Allen Cup Point, U.S.S., ⅜″ x ½″	.07
117979	1	Woodruff Key, No. C	.04

PARTS LIST

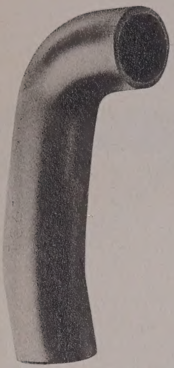
Water Pump Assembly


4R-1764-B
RPORA
RPORG
103322
174850
R-1757-B
R-1763
R-1790
RC-3130

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4LR-9	1	Fresh Water Pump	$30.99
RPORA	1	Water Pump Body	16.00
R-1757-B	1	Water Pump Impeller	8.44
RC-3130	1	Bearing, Marlin Rockwell, No. 5200-FFS-4	1.65
R-1763	1	Water Pump Bearing Housing Cap, Wohlert No. W-1524	.07
R-1790	1	Water Pump Impeller Seal Assembly	.07
4R-1764-B	1	Water Pump Sheave	1.53
RPORG	1	Water Pump Body Gasket	.04
174850	4	Nut, Hex., S.A.E., 7/16″	.02
103322	4	Lock Washer, Medium, 7/16″	.01

PARTS LIST

Cooling System Assembly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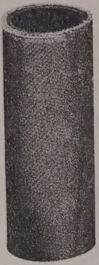
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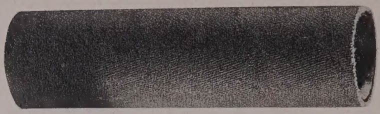
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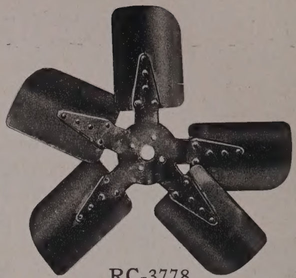
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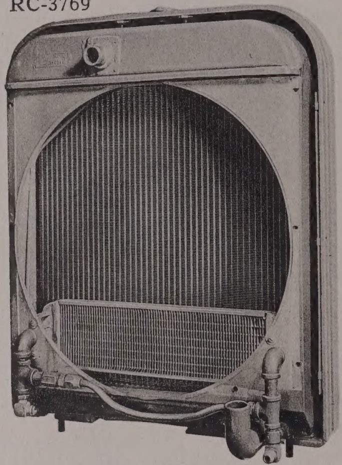
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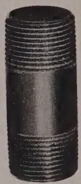
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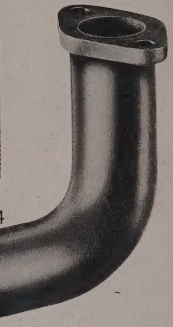
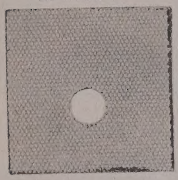

4R-1705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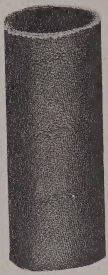
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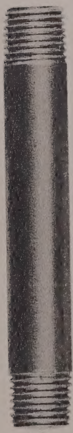
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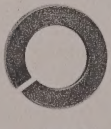
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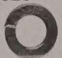
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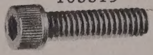
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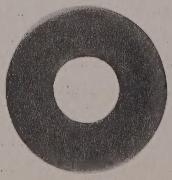
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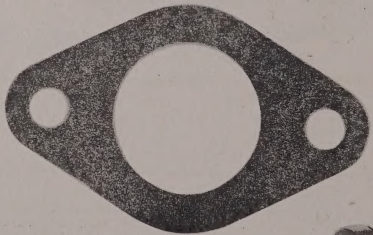
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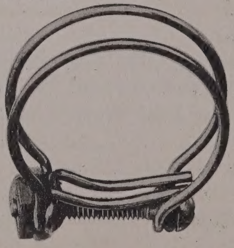
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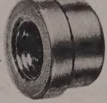
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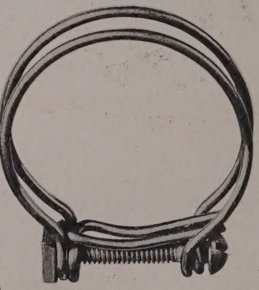
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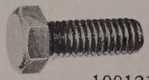
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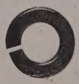
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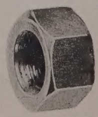
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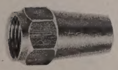
PARTS LIST

Cooling System Assembly

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3770	1	Radiator, Yates, RD-LL-618, with oil cooling section	$74.89
RC-3778	1	Fan, 20″ dia., 5 Blade, No. 92232	2.34
4R-1705	1	Radiator Gland Hose Connection	2.44
R-1791	1	Water Pump Hose Connection Elbow	1.13
R-1705-G	1	Gasket (Gland 4R-1705)	.02
RC-3769	1	Radiator Hose, Dayton, 1½″ x 6½″	.23
RC-3765	1	Radiator Hose, Dayton, 1½″ x 4½″	.20
RC-3760	1	Radiator Hose, Dayton, 1¼″ x 4″	.18
105479	4	Hose Clamps, 1½″	.02
126106	2	Hose Clamps, 1¼″	.02
R-1868	4	Radiator Pads	.02
100121	2	Capscrew, Hex. Head, U.S.S., 5/16″ x ¾″	.02
138202	4	Screw, Knurled Head, U.S.S., Allen, ¼″ x 1″	.11
174802	2	Nut, Hex., S.A.E., ½″	.02
103319	4	Lock Washer, Medium, ¼″	.01
103320	2	Lock Washer, Medium, 5/16″	.01
103323	2	Lock Washer, Medium, ½″	.01
106265	2	Flat Washer, ½″	.01
144594	1	Pipe Nipple, ¼″ x 3½″	.06
127874	1	Pipe Nipple, 1″ x 1½″ long	.13
105411	1	Pipe Cap, ¼″	.05

Water Tubing Assembly

RC-3360



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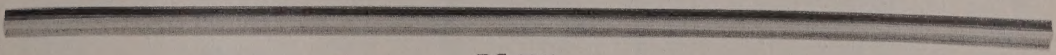
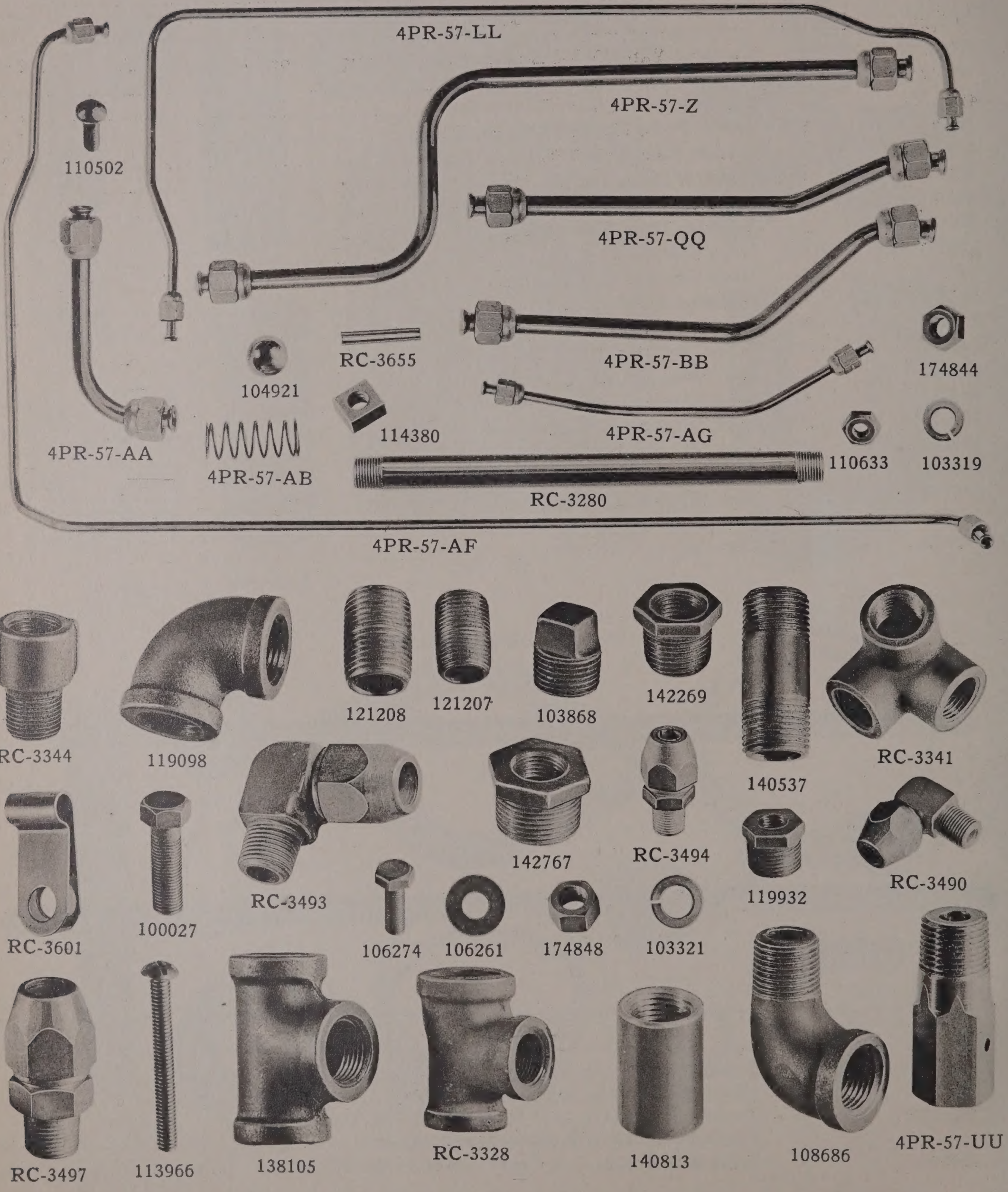


RC-3361

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3360	1	Tubing, ½″ O.D. x .035″ Wall x 16″ Long, Copper (Exhaust Manifold to Water Manifold)	$ 1.78
RC-3361	1	Tubing, ½″ O.D. x .035″ Wall x 18″ Long, Copper (Cylinder Block to Exhaust Manifold)	1.83
118541	4	Tube Nut, S.A.E., ½″, Commonwealth No. 551, Brass	.51

PARTS LIST

Lubricating Oil System Assembly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4PR-57-AA
4PR-57-AB
110633
103319
RC-3280
4PR-57-AF
121208
121207
103868
142269
RC-3344
119098
RC-3341
140537
142767
RC-3494
RC-3601
100027
RC-3493
119932
RC-3490
106274
106261
174848
103321
RC-3497
113966
138105
RC-3328
140813
108686
4PR-57-UU

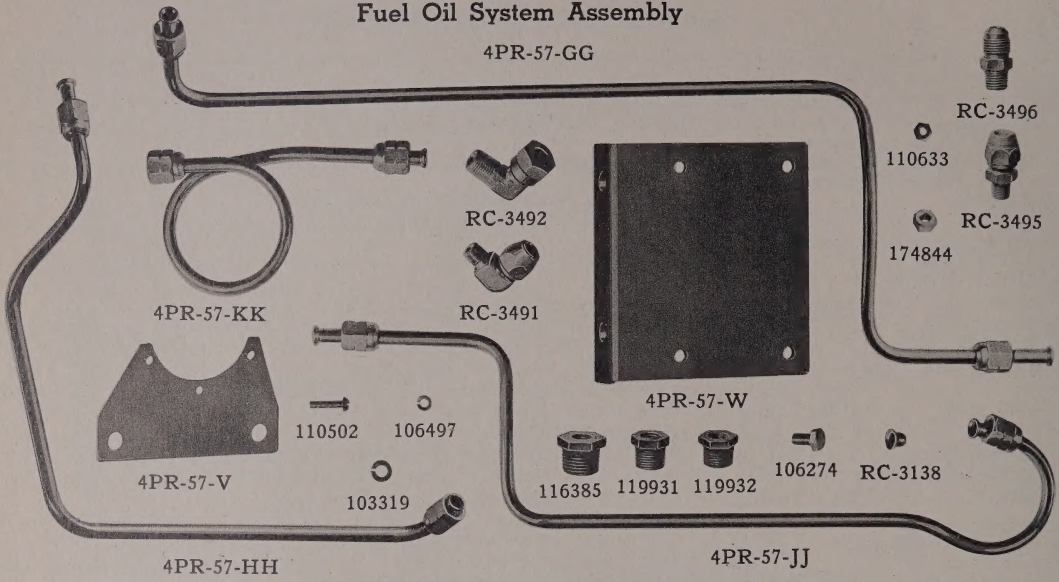
PARTS LIST

Lubricating Oil System Assembly

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3205	1	Lubricating Oil Filter, Cartridge Type, Briggs G-800	$32.50
See Pg. 201 for replacement parts.			
RC-3199	1	Filter Cartridge, Cellulose, G-8-Cel	3.00
See Pg. 201 for replacement parts.			
RC-3196	1	Lubricating Oil Filter, Metal Edge Type Cartridge, Cuno Type G, 1¼″ x 4½″, .0035″ spacing	11.40
See Pg. 202 for replacement parts.			
4PR-57-AE	1	Lubricating Oil Cooler Relief Valve:	2.18
4PR-57-UU	1	Relief Valve Body	.14
4PR-57-AB	1	Relief Valve Spring	.01
104921	1	Relief Valve Ball, 7/16″ dia.	.06
RC-3655	1	Relief Valve Taper Pin, No. 000	.03
4PR-57-AA	1	Tubing, ½″ O.D. x .035″ Wall x 7″ Long, Steel (Engine Base to Metal Edge Filter)	2.90
4PR-57-Z	1	Tubing, ½″ O.D. x .035″ Wall x 20½″ Long, Steel (Metal Edge Filter to Oil Cooler)	3.80
4PR-57-QQ	1	Tubing, ½″ O.D. x .035″ Wall x 14″ Long, Steel (Oil Cooler By-Pass)	3.40
4PR-57-BB	1	Tubing, ½″ O.D. x .035″ Wall x 13″ Long, Steel (Oil Cooler to Engine Base)	3.30
4PR-57-LL	1	Tubing, ¼″ O.D. x .035 Wall x 30⅝″ Long, Steel (Metal Edge Filter to Cartridge Type Filter)	.72
4PR-57-AF	1	Tubing, ¼″ O.D. x .035″ Wall x 42½″ Long, Steel (Cartridge Type Filter to Oil Filler Cup)	2.80
4PR-57-AG	1	Tubing, ¼″ O.D. x .035″ Wall x 10½″ Long, Steel (Engine Base to Engine Governor)	2.30
RC-3497	5	Straight Coupling, Male, for ½″ O.D. Tubing, Hydraulic Devices, No. 503-1SC	.83
RC-3493	3	90° Elbow, Male, for ½″ O.D. Tubing, Hydraulic Devices, No. 503-3LC	1.08
RC-3494	3	Straight Coupling, Male, for ¼″ O.D. Tubing, Hydraulic Devices, No. 251-1SC	.37
RC-3490	1	90° Elbow, Male, for ¼″ O.D. Tubing, Hydraulic Devices, No. 251-3LC	.60
106274	4	Capscrew, Hex. Head, S.A.E., ¼″ x ⅝″	.01
100027	4	Capscrew, Hex. Head, S.A.E., ⅜″ x 1¼″	.02
106261	6	Flat Washer, ¼″	.01
103319	4	Lock Washer, Medium, ¼″	.01
103321	4	Lock Washer, Medium, ⅜″	.01
174844	4	Nut, Hex., S.A.E., ¼″	.01
174848	4	Nut, Hex., S.A.E., ⅜″	.01
113966	2	Stove Bolt, U.S.S., ¼″ x 2¼″	.02
114380	2	Nut, Square, U.S.S., ¼″	.01
110502	2	Machine Screw, No. 10-24 x ¾″	.01
110633	2	Nut, Hex., No. 10-24	.01
119932	1	Bushing, Outside Hex., ⅜″ x ⅛″	.06
142269	1	Bushing, Outside Hex., ½″ x ⅜″	.06
142767	1	Bushing, Outside Hex., ¾″ x ⅜″	.07
121207	1	Close Nipple, ⅜″, Wrought Iron	.04
121208	1	Close Nipple, ½″, Wrought Iron	.05
RC-3341	1	Elbow, Side Outlet, ⅜″	.17
138105	1	Tee, ½″, Malleable Iron	.10
RC-3328	1	Tee, ½″ x ⅜″ x ⅜″, Malleable Iron	.18
119098	2	Elbow, ½″, Malleable Iron	.09
RC-3344	2	Pipe Extension, ⅜″, Malleable Iron	.08
RC-3601	2	Tubing Clip, 5/16″, Single	.01
140537	3	Nipple, ½″ x 2″, Wrought Iron	.05
RC-3280	1	Nipple, ½″ x 12″, Wrought Iron	.15
108686	1	Street Elbow, ½″, Malleable Iron	.09
140813	1	Coupling, ½″, Malleable Iron	.08
103868	1	Pipe Plug, Male, ½″, Cast Iron	.03

PARTS LIST

Fuel Oil System Assembly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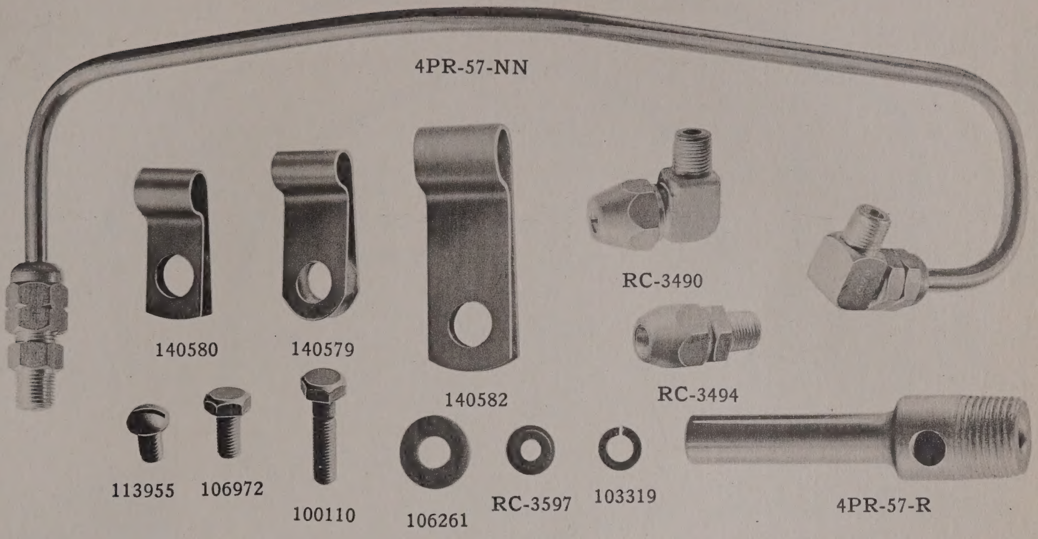
4PR-57-V
103319
116385
119931
119932
106274
RC-3138
4PR-57-HH
4PR-57-JJ

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3176	1	Metal Edge Filter, 1¼" x 1⅝" Cartridge, .0035" spacing, Cuno, Type DS	$6.60
*See Pg. 204 for replacement parts.			
RC-3179	1	Cartridge Type Filter, Fram, F-1104	8.00
*See Pg. 203 for replacement parts.			
4PR-57-V	1	Bracket, Metal Edge Filter	1.17
4PR-57-W	1	Bracket, Cartridge Type Filter	1.71
4PR-57-HH	1	Tubing, 5/16" O.D. x .035" Wall x 24½" Long, Steel (Metal Edge Filter to Fuel Transfer Pump)	2.80
4PR-57-JJ	1	Tubing, 5/16" O.D. x .035" Wall x 23½" Long, Steel (Fuel Transfer Pump to Cartridge Type Filter)	2.60
4PR-57-KK	1	Tubing, 5/16" O.D. x .035" Wall x 14¼" Long, Steel (Cartridge Type Filter to Safety Control)	2.20
4PR-57-GG	1	Tubing, 5/16" O.D. x .035" Wall x 27¾" Long, Steel (Safety Control to Fuel Pump Header)	3.00
RC-3491	6	90° Elbow, Male, for 5/16" O.D. Tubing, Hydraulic Devices, No. 311-3LC	.70
RC-3495	2	Straight Coupling, Male, for 5/16" O.D. Tubing, Hydraulic Devices, No. 311-1SC	.40
RC-3492	1	90° Elbow, Male, ⅜" x ¼", for ⅜" O.D. Tubing	.79
106274	4	Capscrew, Hex. Head, S.A.E., ¼" x ⅝"	.01
106497	3	Lock Washer, Medium, No. 10	.01
103319	4	Lock Washer, Medium, ¼"	.02
110633	3	Nut, Hex., U.S.S., No. 10-24	.01
174844	4	Nut, Hex., S.A.E., ¼"	.01
110502	3	Machine Screw, No. 10-24 x ¾"	.01
RC-3496	1	Straight Fitting, ⅜" x ¼" P.T., Steel	.43
RC-3138	2	Bonnet, ⅜", Copper	.07
116385	1	Bushing, Outside Hex., ½" x ⅛"	.05
119931	1	Bushing, Outside Hex., ⅜" x ¼"	.06
119932	2	Bushing, Outside Hex., ⅜" x ⅛"	.06

PARTS LIST

Safety Control Assembly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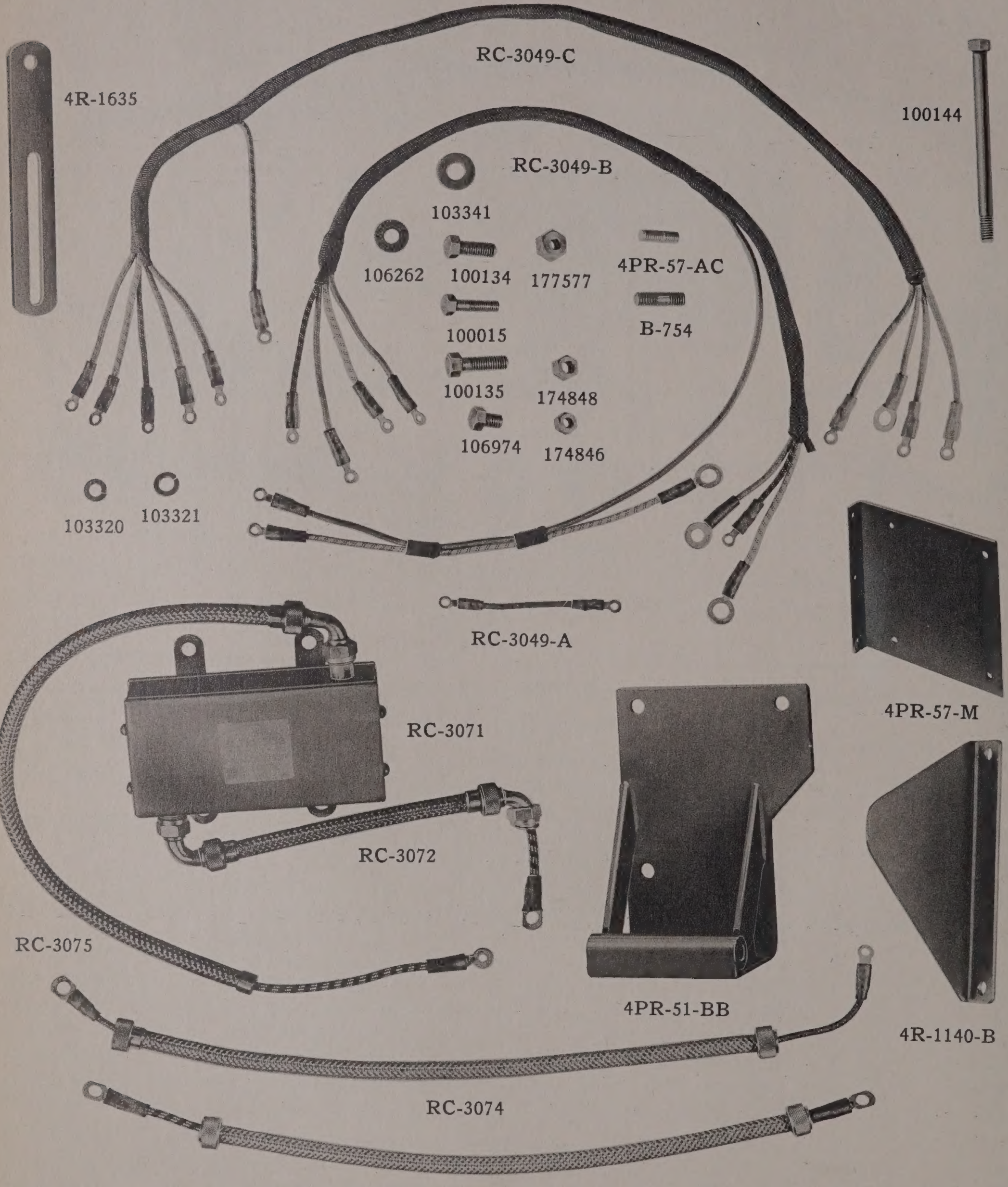
140579
140582
RC-3490
RC-3494
113955
106972
100110
106261
RC-3597
103319
4PR-57-R

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3104	1	Safety Control, Fulton Sylphon No. 530	$36.00
See Pg. 206 for replacement parts.			
4PR-57-R	1	Support Plug, Safety Control	1.08
4PR-57-NN	1	Tubing, ¼″ O.D. x .035″ Wall x 16″ Long, Steel (Engine Base to Safety Control)	.63
RC-3490	1	90° Elbow, Male, for ¼″ O.D. Tubing, Hydraulic Devices, No. 251-3LC	.60
RC-3494	1	Straight Coupling, Male, for ¼″ O.D. Tubing, Hydraulic Devices, No. 251-1SC	.37
100110	2	Capscrew, Hex. Head, U.S.S., ¼″ x 1″	.01
106261	2	Flat Washer, ¼″	.01
RC-3597	2	Pad, Rubber	.01
140582	1	Tubing Clip, ½″	.01
140580	1	Tubing Clip, ⅜″	.01
140579	2	Tubing Clip, 5/16″	.01
113955	1	Stove Bolt, U.S.S., ¼″ x ½″	.01
106972	2	Capscrew, Hex. Head, U.S.S., ¼″ x ½″	.01
103319	2	Lock Washer, Medium, ¼″	.02

PARTS LIST

Electrical Equipment Assembly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RC-3049-A
4PR-57-M
RC-3071
RC-3072
RC-3075
4PR-51-BB
4R-1140-B
RC-3074
RC-3073

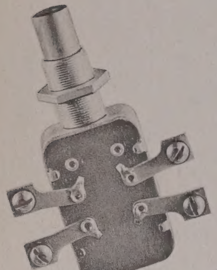
PARTS LIST

Electrical Equipment Assembly

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3056	1	Starting Motor, Electric Auto-Lite, 24 Volt, MBD-4011	$200.00
See Pg. 210 for replacement parts.			
RC-3057	1	Charging Generator, Electric Auto-Lite, 24 Volt, GDW-4607A	170.00
See Pg. 215 for replacement parts.			
RC-3058	1	Voltage Regulator, Electric Auto-Lite, VAH-4001A	75.00
See Pg. 219 for replacement parts.			
RC-3071	1	Filterette, Electric Auto-Lite, 1107-WDE	60.00
RC-3072	1	Cable, Electric Auto-Lite, SP-1644 (Filterette to Voltage Regulator)	5.00
RC-3073	1	Cable, Electric Auto-Lite, SP-1645 (Charging Generator Armature to Voltage Regulator Armature Connection)	6.20
RC-3074	1	Cable, Electric Auto-Lite, SP-1646 (Charging Generator Field to Voltage Regulator Field Connection)	15.20
RC-3075	1	Cable, Electric Auto-Lite, SP-1674 (Filterette to Ammeter Gauge)	7.00
RC-3049-A	1	Jumper Harness	.65
RC-3049-B	1	Small Harness, Safety Control	1.19
RC-3049-C	1	Large Harness, Starting Motor	1.29
4PR-51-BB	1	Bracket, Charging Generator	4.05
4R-1140-B	1	End Bracket, Charging Generator	1.44
4R-1635	1	Belt Tightener, Charging Generator	.18
4PR-57-M	1	Bracket, Voltage Regulator	1.71
B-754	3	Combination Stud, ⅜″ x 1-5/16″	.06
4PR-57-AC	4	Stud, 5/16″ x 11/16″	.03
100015	4	Capscrew, Hex. Head, S.A.E., 5/16″ x 1¼″	.02
100134	1	Capscrew, Hex. Head, U.S.S., ⅜″ x 1″	.02
100135	4	Capscrew, Hex. Head, U.S.S., ⅜″ x 1¼″	.02
100144	1	Capscrew, Hex. Head, U.S.S., ⅜″ x 5″	.09
106974	1	Capscrew, Hex. Head, U.S.S., ⅜″ x ½″	.02
103320	4	Lock Washer, Medium, 5/16″	.01
103321	9	Lock Washer, Medium, ⅜″	.01
106262	12	Flat Washer, 5/16″	.02
103341	1	Flat Washer, ⅜″	.02
174846	8	Nut, Hex., S.A.E., 5/16″	.01
174848	4	Nut, Hex., S.A.E., ⅜″	.01
177577	4	Jam Nut, U.S.S., ⅜″	.01

PARTS LIST

Engine Instrument Panel Assembly



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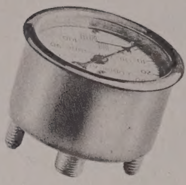

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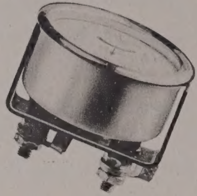

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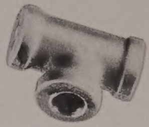

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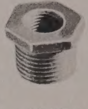

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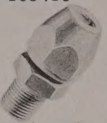

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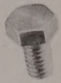

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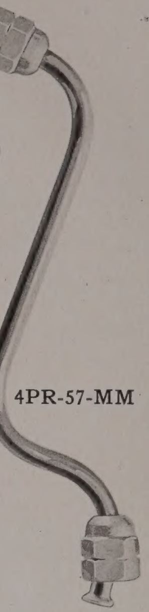

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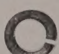

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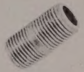

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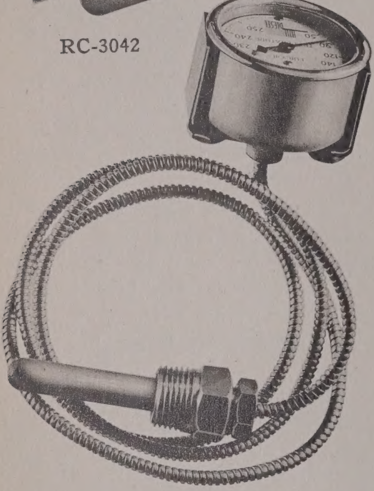

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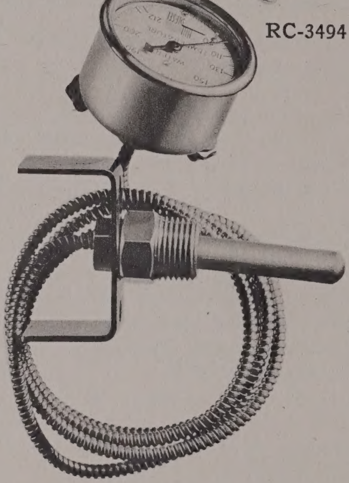

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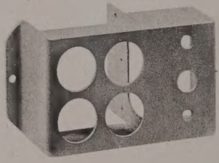

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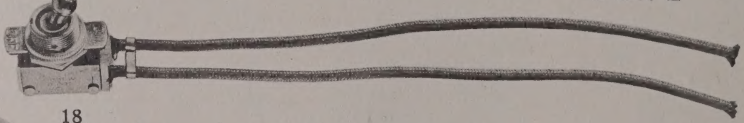

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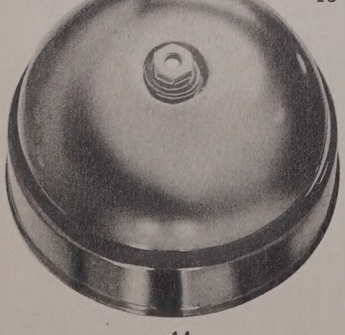

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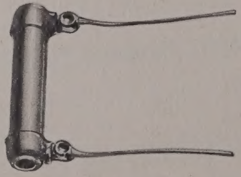

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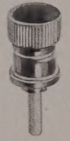

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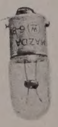

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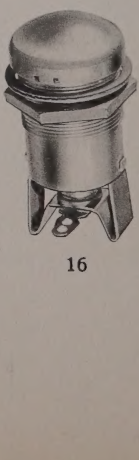


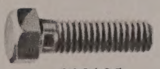
16

PARTS LIST

Engine Instrument Panel Assembly

REFERENCE NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	4PR-57-L	1	Instrument Panel	$ 3.35
2	RC-3044	1	Ammeter Gauge, 30-30	2.50
3	RC-3106	1	Lube Oil Pressure Gauge, 0-100 lbs.	1.30
4	RC-3107	1	Water Temperature Gauge, 90°-212°F.	4.20
5	RC-3112	1	Lube Oil Temperature Gauge, 50°-250° F.	4.20
6	RC-3042	1	Push Button, Electric Auto-Lite, No. XA-572	12.50
7	4PR-57-MM	1	Tubing, ¼" O.D. x .035" Wall x 8" Long, Steel (Engine base to instrument panel)	.50
8	RC-3494	2	Straight Coupling, Male, for ¼" O.D. Tubing	.37
9	106973	2	Capscrew, Hex. Head, U.S.S., 5/16" x ½"	.02
10	103320	2	Lock Washer, Medium, 5/16"	.01
11	105416	1	Tee, ⅛", Malleable Iron	.13
12	119932	1	Bushing, Outside Hex., ⅜" x ⅛", Malleable Iron	.06
13	105404	1	Close Nipple, ⅛", Cast Iron	.04
14		1	Alarm Bell, 3"-24V D.C., Schwarze No. 304	3.40
15		1	Resistor, 100 ohm, 10W., Ohmite, Brown Devil	.40
16		1	Indicating Light, 1" Green, Drake No. 275	1.30
17		2	Binding Post, No. 41 Commander P-4	.40
18		1	Toggle Switch, 3A, 250V., Hart and Hageman No. 20599	1.00
19		1	Indicating Lamp, Westinghouse No. 44	.09

Driven Equipment Assembly



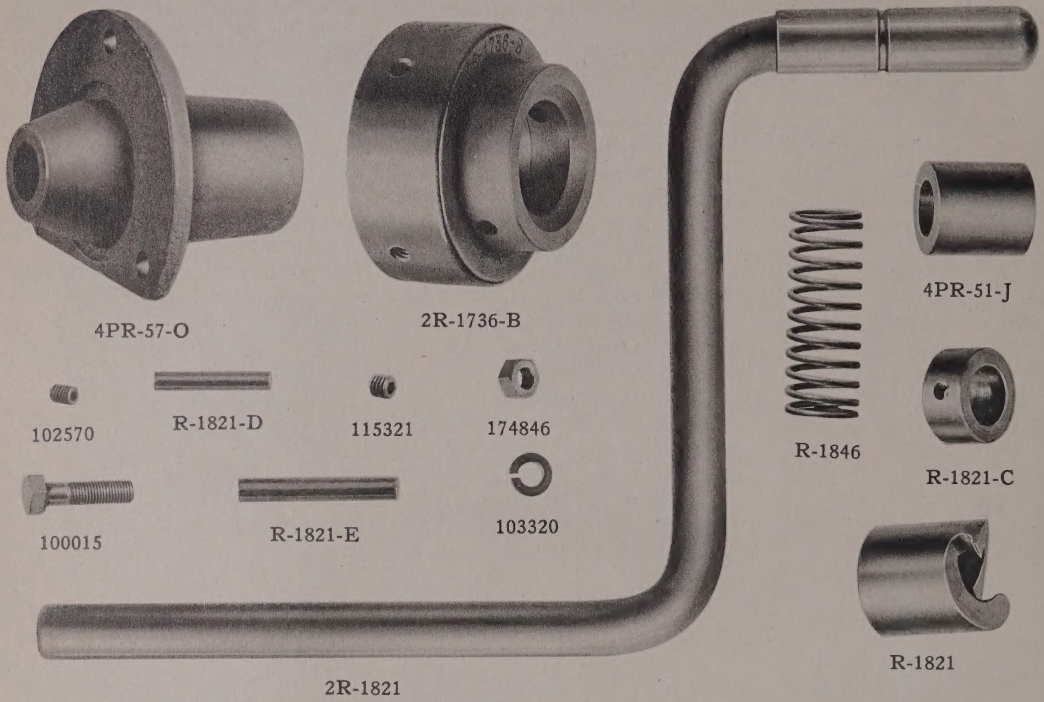
100135

103321

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3069	1	15 KW, 8PF, Single Phase 60 cycle, 1200 R.P.M., 120/240V. Two Bearing Streamlined, A.C. Generator with Direct Connected Exciter, General Electric Drawing, No. M-588713	——
See Pg. 230 for replacement parts.			
RC-3620	1	Flexible Coupling, Thomas, No. 225CM	$83.52
See Pg. 205 for replacement parts.			
100135	20	Capscrew, Hex. Head, U.S.S., ⅜" x 1¼"	.02
103321	20	Lock Washer, Medium, ⅜"	.01

PARTS LIST

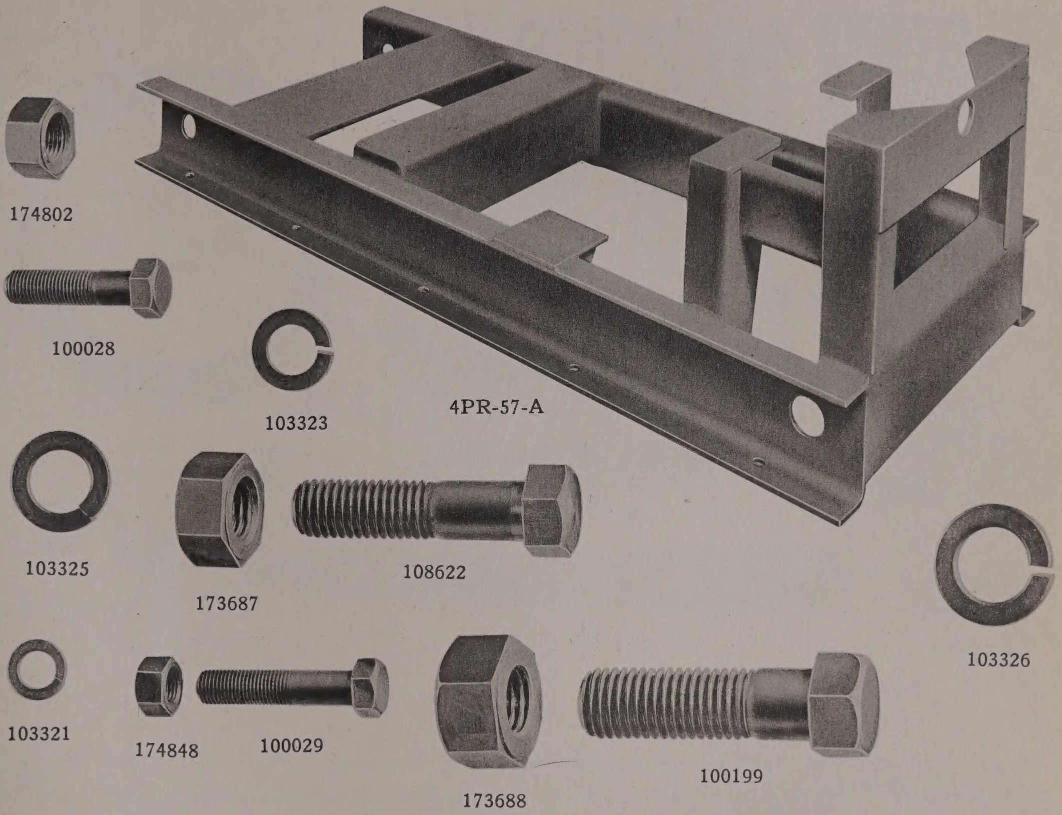
Hand Starting Equipment Assembly


4PR-57-O
2R-1736-B
4PR-51-J
102570
R-1821-D
115321
174846
R-1846
R-1821-C
100015
R-1821-E
103320
R-1821
2R-1821

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
R-1821	1	Hand Crank Hub	$ .14
R-1821-C	1	Crank Collar	.27
2R-1821	1	Hand Crank	.72
R-1821-D	1	Hand Crank Pin	.02
R-1821-E	1	Hub Pin for Hand Crank	.02
R-1846	1	Hand Crank Release Spring	.02
2R-1736-B	1	Hand Cranking Hub	4.15
4PR-51-J	1	Hand Crank Bearing	.27
4PR-57-O	1	Hand Crank Bearing Housing	5.20
100015	3	Capscrew, Hex. Head, S.A.E., 5/16″ x 1¼″	.02
103320	3	Lock Washer, Medium, 5/16″	.01
174846	3	Nut, S.A.E., 5/16″	.01
115321	4	Set Screw, Allen Head, Cup Point, U.S.S., 5/16″ x 5/16″	.06
102570	2	Set Screw, Allen Head, Cup Point, U.S.S., ¼″ x ⅜″	.06

PARTS LIST

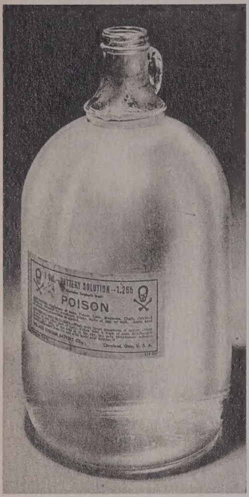
Subbase and Support Assembly


174802
100028
103323
4PR-57-A
103325
173687
108622
103326
103321
174848
100029
173688
100199

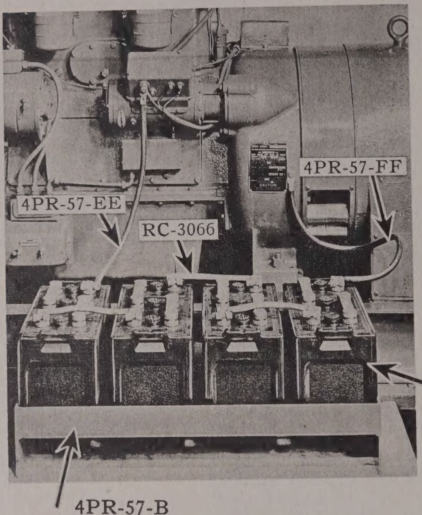
PART NUMBER	QUANTITY	PART NAME	PRICE EACH
4PR-57-A	1	Subbase	$98.42
100029	2	Capscrew, Hex. Head, S.A.E., ⅜″ x 1¾″	.02
108622	4	Capscrew, Hex. Head, U.S.S., ⅝″ x 2¾″	.08
100199	2	Capscrew, Hex. Head, U.S.S., ¾″ x 2½″	.11
103321	3	Lock Washer, Medium, ⅜″	.01
103323	6	Lock Washer, Medium, ½″	.01
103325	4	Lock Washer, Medium, ⅝″	.01
103326	2	Lock Washer, Medium, ¾″	.01
174848	3	Nut, Hex., S.A.E., ⅜″	.01
174802	6	Nut, Hex., S.A.E., ½″	.02
173687	4	Nut, Hex., U.S.S., ⅝″	.04
173688	2	Nut, Hex., U.S.S., ¾″	.01
100028	1	Capscrew, Hex. Head, S.A.E., ⅜″ x 1½″	.02

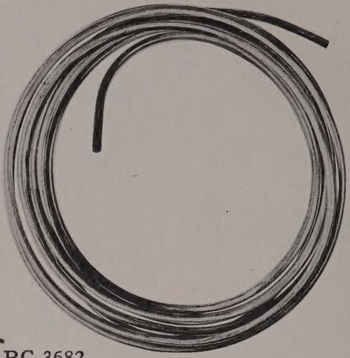
PARTS LIST

Miscellaneous Items That Accompany Power Unit



RC-3663



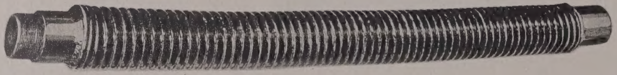


RC-3671

119931

RC-3492

RC-3496



RC-3658

PART NUMBER	QUANTITY	PART NAME	PRICE EACH
RC-3671	1	Tubing, ⅜″ O.D. x 30′ Long, Copper	$ 4.86
RC-3496	2	Straight Fitting, ⅜″ x ¼″, Steel	.43
RC-3492	2	90° Elbow, ⅜″ x ¼″, Steel	.79
119931	3	Pipe Bushing, ⅜″ x ¼″	.06
RC-3658	1	Flexible Exhaust Hose, 2½″ dia. x 3′ Long, Steel	19.62
RC-3809	1	Exhaust Muffler, (Maxim No. 5SC)	71.00
See Pg. 208 for replacement parts.			
4PR-57-B	1	Battery Rack	13.34
4PR-57-EE	1	Battery Cable, Positive, 30″ Long	.65
4PR-57-FF	1	Battery Cable, Negative, 24″ Long	.56
RC-4465	1	Switchboard, Kirkhof Electric Company	645.00
See Pg. 222 for replacement parts.			
RC-3663	6	1-Gallon Bottle Electrolyte	1.50
RC-3682	4	Battery, Dry Charged, Exide No. XHM-25	25.00
RC-3066	3	Battery Jumpers, 8½″ Long	.50
RC-3181	40	Fram Filter Cartridge, C-1104-H	1.75
RC-3199	40	Briggs Filter Cartridge, G-8-Cel	3.00

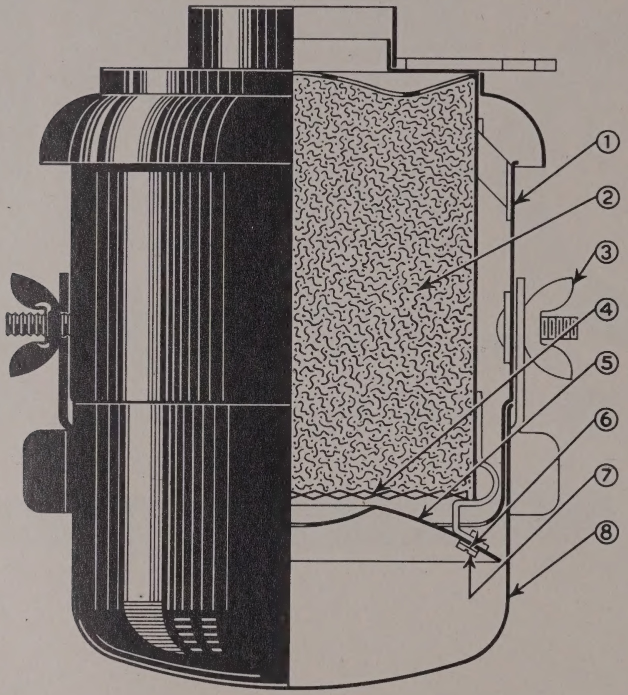
SECTION II

SUBCONTRACTORS PARTS LIST

SUBCONTRACTORS PARTS LIST

Oil Bath Air Cleaner, Model T045-11700

MANUFACTURE BY THE UNITED SPECIALTIES COMPANY, CHICAGO, ILLINOIS

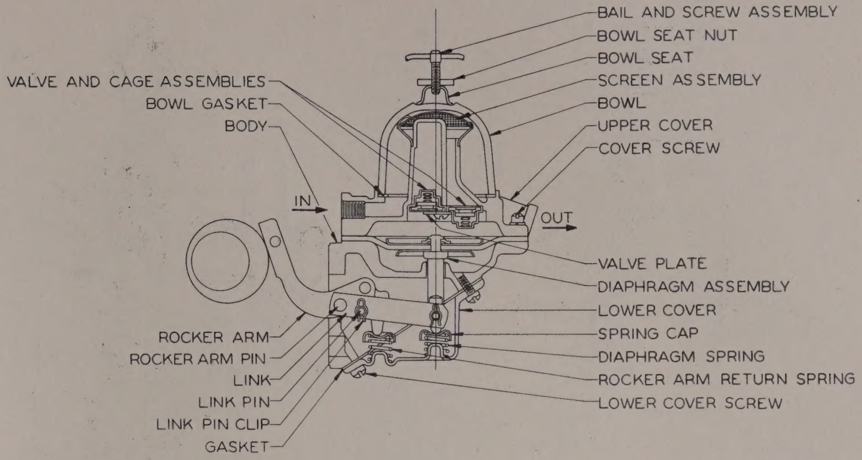


REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	B-11794	1	Body and Wing Nut Assembly	$1.80
2	A-8057	1	Filter Element	.54
3	A-7019	2	Wing Nut	.02
4	B-6575	1	Lower Screen	.06
5	A-9030	1	Baffle	.09
6	A-1441	1	Shakeproof Lockwasher	.01
7	A-8978	1	Self Tapping Screw	.02
8	9048	1	Oil Cup and Clip	.36

SUBCONTRACTORS PARTS LIST

Fuel Transfer Pump, Model AC1523378

MANUFACTURED BY THE A.C. SPARK PLUG DIVISION, G.M.C., FLINT, MICHIGAN

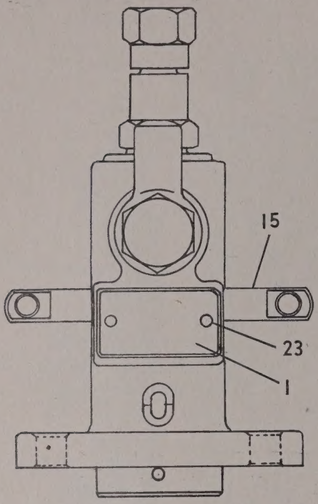

BAIL AND SCREW ASSEMBLY
BOWL SEAT NUT
BOWL SEAT
VALVE AND CAGE ASSEMBLIES
SCREEN ASSEMBLY
BOWL GASKET
BOWL
BODY
UPPER COVER
COVER SCREW
IN
OUT
VALVE PLATE
DIAPHRAGM ASSEMBLY
LOWER COVER
ROCKER ARM
SPRING CAP
ROCKER ARM PIN
DIAPHRAGM SPRING
LINK
ROCKER ARM RETURN SPRING
LINK PIN
LOWER COVER SCREW
LINK PIN CLIP
GASKET

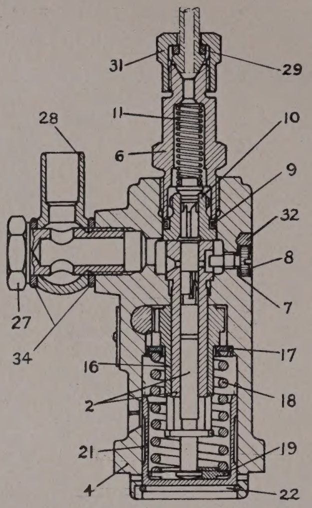
REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	1523112	1	Diaphragm Assembly	$0.25
	848429	2	Rocker Arm Pin Retaining Ring	.01
	856035	1	Rocker Arm Pin	.04
	856081	1	Rocker Arm	2.90
	1521085	1	Body	1.80
	132696	1	Valve Plate Screw	.02
	855574	2	Link	.02
	855016	2	Link Pin	.02
	855017	4	Link Pin Clip	.20/C
	855253	1	Rocker Arm Spring	.02
	1521187	1	Diaphragm Spring	.03
	855573	1	Bottom Cover	.15
	132108	3	Bottom Cover Screw	.50/C
	855532	2	Spring Cap	.01
	855585	1	Bottom Cover Gasket	.03
	855493	10	Top Cover Screw	.01
	855064	10	Top Cover Screw Lockwasher	.01
	1523106	2	Valve and Cage Assembly	.15
	1521945	1	Glass Bowl	.20
	1521953	2	Valve Cage Gasket	.01
	1521946	1	Bowl Gasket	.10
	1537212	1	Screen Assembly	.40
	854005	1	Bowl Seat	.01
	1521989	1	Bail and Screw Assembly	.20
	1521956	1	Valve Plate	.20
	855763	1	Bail Thumb Nut	.05
	1537075	1	Top Cover	1.15
	1521377	1	Priming Lever	.35

SUBCONTRACTORS PARTS LIST

Fuel Injection Pump, Model APF-1A-80A-S54

MANUFACTURED BY AMERICAN BOSCH CORPORATION, SPRINGFIELD, MASSACHUSETTS



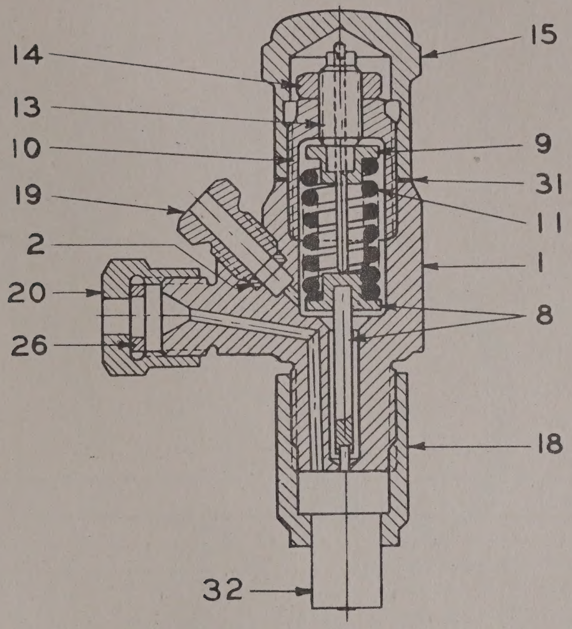


REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	NP 7630	1	Name Plate	$ .10
2	BC 7635-3 A	1	Plunger and Barrel Assembly — 8 mm dia.	11.00
4	HG 76103	1	Pump Housing	10.80
6	HP 7623	1	Delivery Valve Holder	1.10
7	WNS 2034/4 X	1	Barrel Set Screw Gasket	.10
8	WSR 2099/2 X	1	Barrel Set Screw	.10
9	WNR 2021/3 X	1	Delivery Valve Holder Gasket	.10
10	VA 7636 A	1	Delivery Valve and Seat	3.60
11	SP 7617	1	Delivery Valve Spring	.30
15	RD 7651	1	Control Rod	1.60
16	PMB 2/2 X	1	Control Sleeve — toothed	1.75
17	PMS 7/2 X	1	Plunger Spring Seat — upper	.40
18	WSF 2205A1 X	1	Plunger Spring	.95
19	PMS 6/1 X	1	Plunger Spring Seat — lower	.95
21	PMH 1/1 X	1	Slidable Plunger Guide	2.00
22	WMR 2055/3 X	1	Split Ring	.10
23	SC 150-2	2	Drive Rivet for Name Plate	.05
27	NRV 11/1 X	1	Inlet Union Retaining Screw	.40
28	FI 7616	1	Fuel Inlet Union	.75
32	PG 763	1	Lead Plug	.05
34	WMR 2041/7 X	1	Gaskets for Fuel Inlet Union	.05
**	CV 7677A	1	Inspection Window Cover with Gasket	.20
**	GA 7695	1	Gasket only	.10
**	SC 22-5 CA	2	Screws for fastening Inspection Window Cover	.05
**	WMS 2055/400 X	2	Washer for fastening Screws	.05

SUBCONTRACTORS PARTS LIST

Fuel Injection Nozzle Holder, Model AKB-35-SD173

MANUFACTURED BY AMERICAN BOSCH CORPORATION, SPRINGFIELD, MASSACHUSETTS



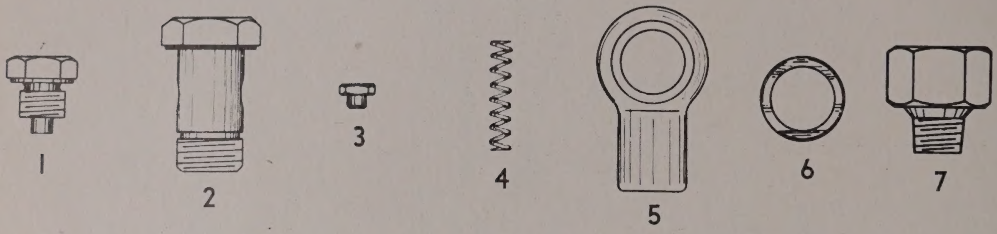
REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	*PDH 16/1 X	1	Nozzle Holder Body	$ 5.25
2	WMR 2072/3 X	1	Gasket for Leak-off Nipple Nut	.05
8	WBO 2057/5 Z	1	Spindle with Lower Spring Seat	.60
9	GU 782	1	Upper Spring Seat	.25
10	WVU 2034/1 X	1	Spring Retaining Cap Nut	.85
11	WSF 2044A4 X	1	Pressure Adjusting Spring	.75
13	WSR 2139/400 X	1	Pressure Adjusting Screw	.15
14	WMU 2066/1 X	1	Lock Nut for Pressure Adjusting Screw	.10
15	WMU 2096/1 X	1	Protection Cap	.45
18	WMU 2065/1 X	1	Nozzle Cap Nut	1.35
19	WMB 2079/1 X	1	Leak-off Nipple Nut	.25
31	WMR 2041/2 X	1	Gasket under Protection Cap	.10
32	ADN 4SD24	1	Nozzle Assembly (must be ordered separately)	11.00

*14 mm x 1.5 thread on inlet connection

SUBCONTRACTORS PARTS LIST

Check Valve Assembly, Model PVE-1A2-Z

MANUFACTURED BY AMERICAN BOSCH CORPORATION, SPRINGFIELD, MASSACHUSETTS

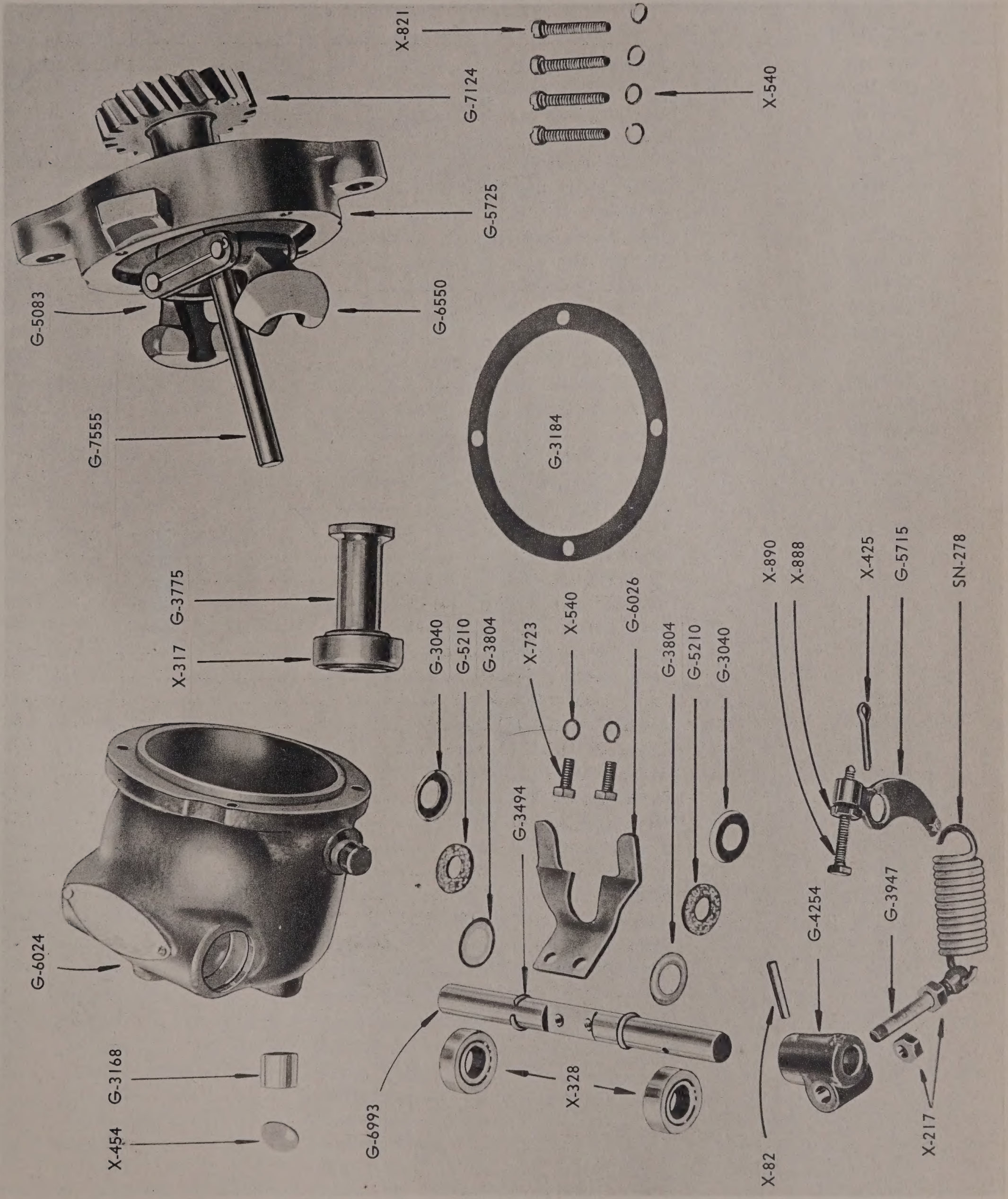


REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	PSR-1A1-X	1	Valve Screw	$0.40
2	WRV-6A1-X	1	Retaining Screw	.90
3	PVE-48/2-X	1	Valve Plate	.25
4	WSF-2215/1	1	Valve Spring	.15
5	NRV-3A1-X	1	Angular Union	.75
6	WMR-2041/7-X	1	Gasket	.05
7	WRV-5A1-X	1	Reduction Nipple	.50

SUBCONTRACTORS PARTS LIST

Engine Governor, Model GC-438

MANUFACTURED BY PIERCE GOVERNOR COMPANY, ANDERSON, INDIANA


X-821
G-7124
X-540
G-5725
G-5083
G-6550
G-7555
G-3184
X-317
G-3775
G-3040
G-5210
G-3804
X-723
X-540
G-6026
G-3804
G-5210
G-3040
X-890
X-888
X-425
G-5715
SN-278
G-3494
G-6024
G-4254
G-3947
G-3168
X-454
G-6993
X-328
X-82
X-217

SUBCONTRACTORS PARTS LIST

Engine Governor, Model GC-438

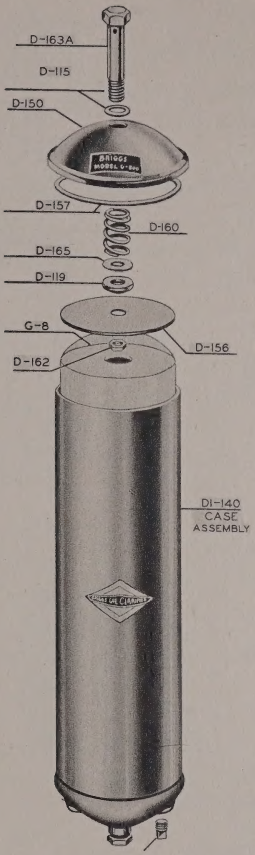
MANUFACTURED BY PIERCE GOVERNOR COMPANY, ANDERSON, INDIANA

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	G-3040	2	Bearing Retainer	$0.35
	G-3168	1	Drive Shaft Bushing	.30
	G-3184	1	Body Gasket	.10
	G-3494	2	Snap Ring	.06
	G-3775	1	Thrust Sleeve	2.75
	G-3804	2	Bearing Spacing Washer	.30
	G-3947	1	Adj. Screw ¼-28 x 2	.50
	G-4254	1	Adj. Screw Bracket	.70
	G-5083	2	Weight Pin	.30
	G-5085	2	Weight Pin Wire	.04
	G-5210	2	Oil Retaining Washer	.10
	G-5493	1	Spider	2.10
	G-5715	1	Adjusting Lever	.70
	G-7555	1	Spider Shaft	1.20
	G-6024	1	Governor Body	6.00
	G-6026	1	Yoke	1.80
	G-6993	1	Rocker Shaft	.50
	G-7124	1	Gear (Furnished by Hill Diesel)	2.34
	G-7484	1	Body Cap	4.50
	SN-278	1	Governor Spring	.72
	G-6550	2	Governor Weight	1.90
	X-51	1	Taper Pin No. 0 x 1" (Gear)	.08
	X-82	1	Taper Pin No. 1 x ⅞ (Adj. Sc. Brkt)	.07
	X-217	2	Hex. Nut ¼-28 (Adj. Screw)	.06
	X-310	1	Ball Bearing (Body Cap)	1.80
	X-317	1	Ball Bearing (Sleeve)	1.30
	X-328	2	Ball Bearing (Rocker Shaft)	.50
	X-346	4	Needle Bearing (Weights)	.60
	X-425	1	Cotter Pin (Adj. Lever)	.03
	X-454	1	Welch Plug 9/16 (Body)	.06
	X-455	2	Escutcheon Pin	.03
	X-461	2	Woodruff Key No. 2	.12
	X-540	6	No. 10 Lock Washer	.06
	X-560	3	Flat Hd. Screw 8-32 x ½	.05
	X-581	1	Name Plate	.10
	X-723	2	Hex. Hd. Screw No. 10-32 x 7/16 (Yoke)	.05
	X-821	4	No. 10-24 x 1 Fil. Hd. Screw (Body)	.10
	X-888	1	Hex. Nut No. 12-24	.03
	X-890	1	Hex. Mach. Screw No. 12-24 x 1½	.15
	X-935	1	Groov-pin ⅛ x ⅞ (Spider)	.10

SUBCONTRACTORS PARTS LIST

Cartridge Type Lubricating Oil Filter, Model G-800

MANUFACTURED BY BRIGGS CLARIFIER COMPANY, WASHINGTON, D. C.

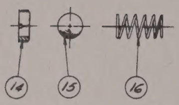

D-163A
D-115
D-150
BRIGGS
MODEL G-800
D-157
D-160
D-165
D-119
G-8
D-156
D-162
DI-140
CASE
ASSEMBLY
BRIGGS OIL CLARIFIER

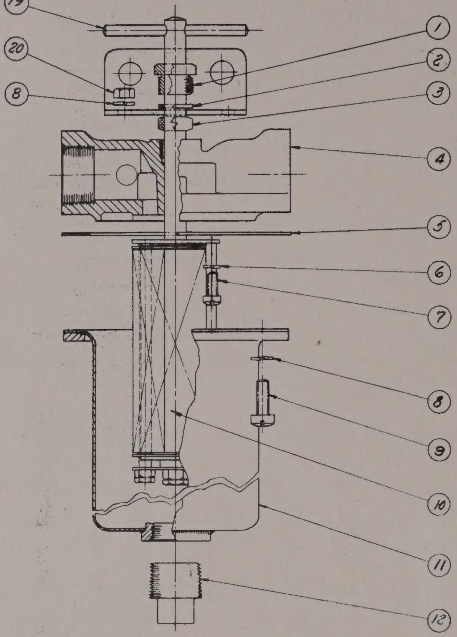
REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	D163A	1	Cap Screw	$1.00
	D-115	1	Copper Washer	.03
	D-150	1	Cover	1.00
	D-157	1	Cover Gasket	.25
	D-160	1	Spring	.25
	D-165	1	Steel Washer	.03
	D-119	1	Cork Washer	.03
	G-8-Cel.	1	Cartridge	3.00
	D-156	1	Sealing Plate	.30
	D-162	1	Jam Nut	.10

SUBCONTRACTORS PARTS LIST

Metal Edge Lubricating Oil Filter, Type G

MANUFACTURED BY CUNO ENGINEERING CORP., MERIDEN, CONNECTICUT

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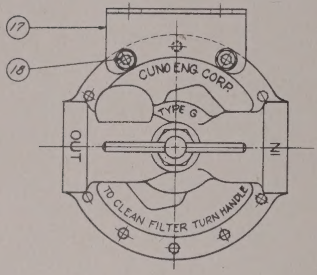
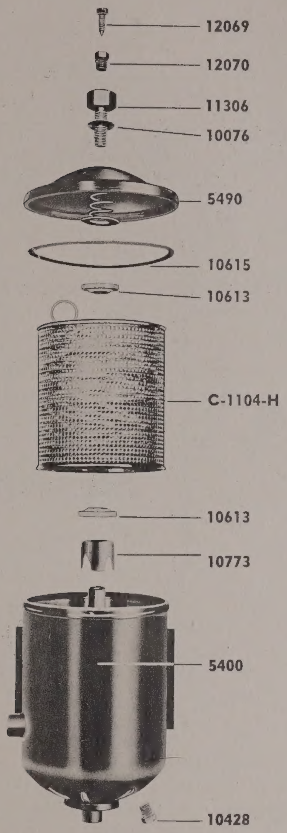

17
18
CUNO ENG CORP
TYPE G
OUT
IN
TO CLEAN FILTER TURN HANDLE

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	F-1258	1	Nut, Gland	$0.15
2	F-745	1	Follower, Gland Nut	.08
3	1334-8	1	Packing	.05
4		1	Head Casting	4.50
5	8262	1	Gasket, Sump	.05
6	B-112	2	Lock Washer, Cartridge Mounting Screw	.02
7	5975	2	Screw, Cartridge Mounting	.02
8	F-268	10	Lock Washer, Sump Screw	.02
9	5055	8	Screw, Sump-short	.02
10	10652	1	Cartridge Assembly	7.40
11	6944-U	1	Sump Assembly with drain plug	2.00
12	F-359	1	Plug, Drain	.05
14	F-360	1	Seat, Relief Valve	.08
15	F-292	1	Ball, Relief Valve	.02
16	F-417	1	Spring, Relief Valve	.04
17	1212-2	1	Bracket, Mounting	.30
18	6940	2	Screw, Sump-long	.02
19	F-136	1	Handle	.02
20	F-762	2	Nut, Mounting Bracket	.02

SUBCONTRACTORS PARTS LIST

Cartridge Type Fuel Oil Filter, Model F-1104-H

MANUFACTURED BY FRAM CORP., EAST PROVIDENCE, RHODE ISLAND

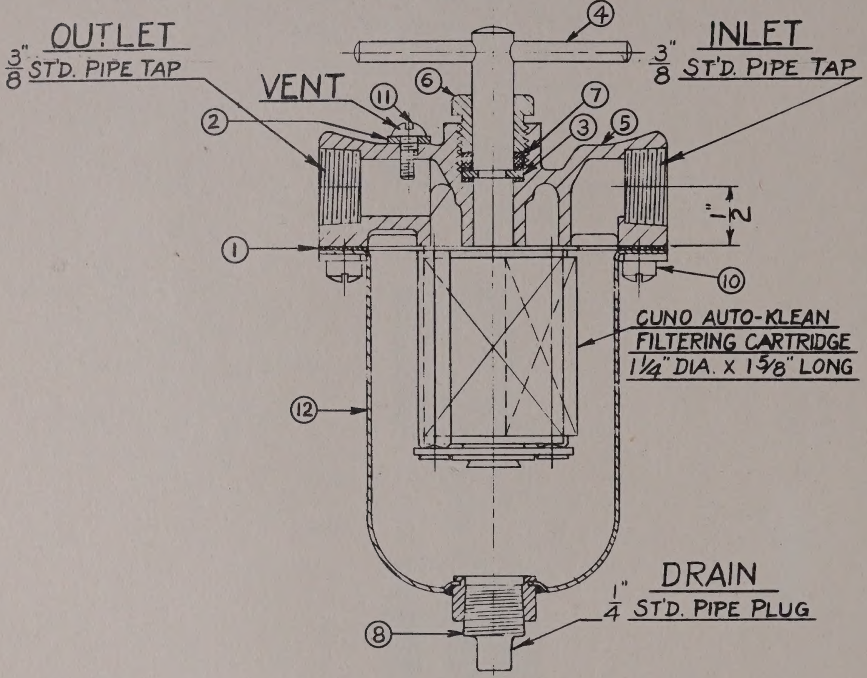

12069
12070
11306
10076
5490
10615
10613
C-1104-H
10613
10773
5400
10428

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	12069	1	Air Vent Screw	$0.25
	12070	1	Air Vent Body	.50
	11306	1	25270 Cap Screw	.75
	10076	1	Fibre Gasket	.05
	5490	1	Cover Assembly	1.00
	10615	1	Cover Gasket	.10
	10613	1	Cork Gasket	.03
	C-1104-H	1	Cartridge	1.75
	10613	1	Cork Gasket	.03
	10773	1	Cartridge Spacer	.10
	5440	1	Body Assembly	4.00
	10428	1	Drain Plug	.10

SUBCONTRACTORS PARTS LIST

Metal Edge Fuel Oil Filter, Type DS

MANUFACTURED BY CUNO ENGINEERING CORP., MERIDEN, CONNECTICUT

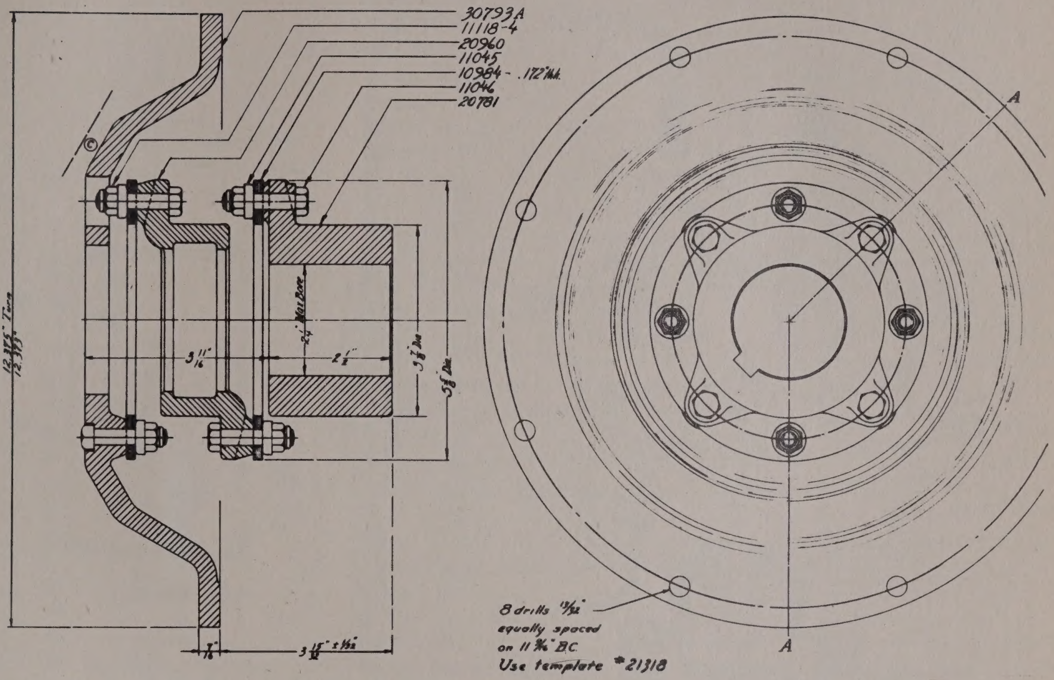

OUTLET
3/8" ST'D. PIPE TAP
VENT
INLET
3/8" ST'D. PIPE TAP
④
⑥
⑪
②
⑦
③
⑤
1/2"
①
⑩
CUNO AUTO-KLEAN
FILTERING CARTRIDGE
1¼" DIA. X 1⅝" LONG
⑫
DRAIN
1/4" ST'D. PIPE PLUG
⑧

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	22214	1	Gasket, Head	$0.02
2	23004	1	Gasket, Vent Screw	.02
3	F-745	1	Gland	.08
4	F-136	1	Handle	.02
5	11569-15-U	1	Head and Cartridge Assembly	5.75
6	F-1258	1	Nut, Gland	.15
7	1334-8	1	Packing	.05
8	F-817	1	Plug, Drain	.05
	22215	1	Ring Sump Retaining	.05
10	24123	6	Screw, Head	.05
11	23003	1	Screw, Vent	.02
12	22342-U	1	Sump	1.25
	F-623	2	Washer Thrust (only 1 accessible for replacement)	.02

SUBCONTRACTORS PARTS LIST

Flexible Coupling, Model 225-CM

MANUFACTURED BY THOMAS FLEXIBLE COUPLING CO., WARREN, PENNSYLVANIA

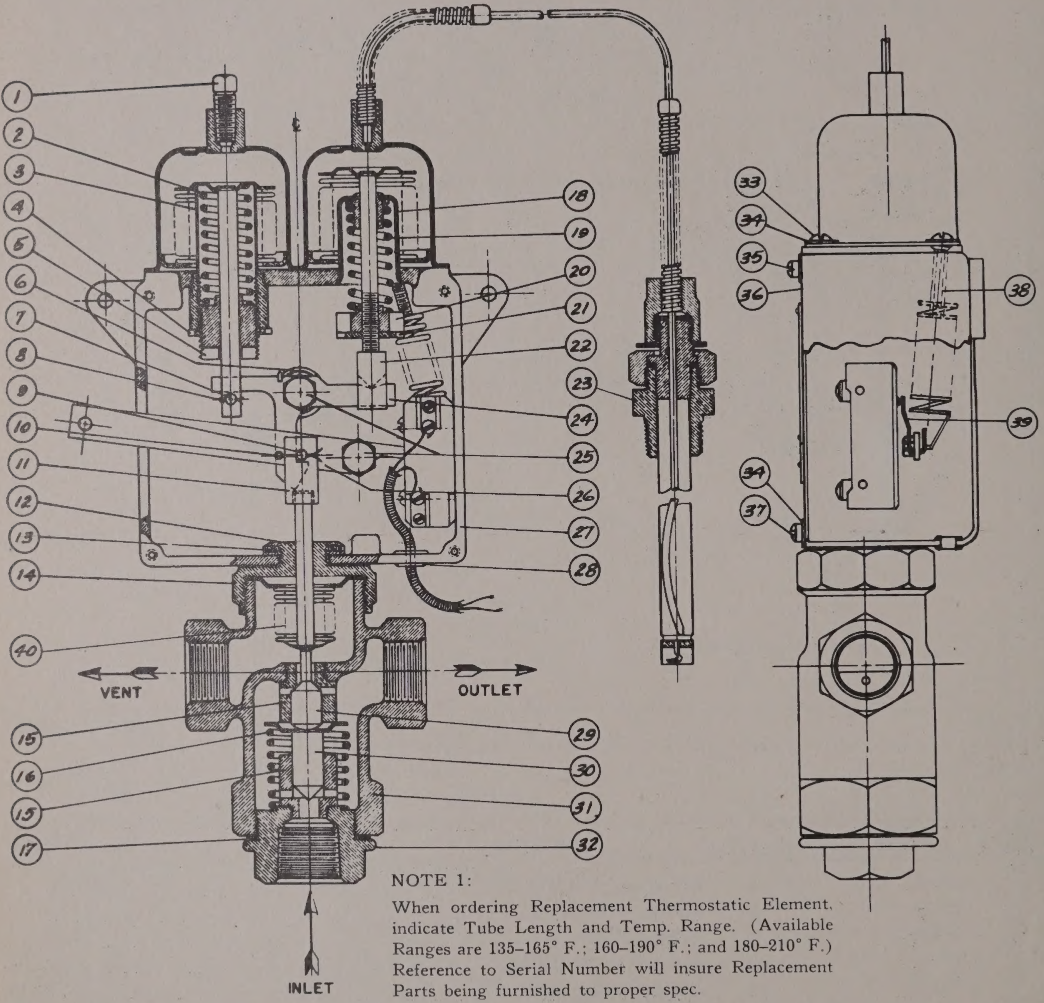

30793A
11118-4
20960
11045
10984 - .172"thk.
11046
20781
12.375" Turn
12.373"
3 11/16"
2 1/4" Max Bore
2 1/2"
3 7/8" Dia
5 5/8" Dia
7/16"
3 15/32"
A
A
8 drills 13/32"
equally spaced
on 11 3/16" B.C.
Use template *21318

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	30793	1	Flywheel Adapter	$40.70
	20781	1	Flange — bore	20.10
	20960	1	Center Ring	10.72
	10984	20	Discs No. 26 USG	9.60/set
	11045	16	Distance Pieces	1.38/set
	11046	16	Lam. Bolts	5.70/set
	11118-4	16	Stay-on Nuts 3/16″ N.F. thd.	2.56/set

SUBCONTRACTORS PARTS LIST

Safety Control, Model No. 530

MANUFACTURED BY THE FULTON SYLPHON COMPANY, KNOXVILLE, TENNESSEE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VENT
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OUTLET
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INLET
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NOTE 1:

When ordering Replacement Thermostatic Element, indicate Tube Length and Temp. Range. (Available Ranges are 135–165° F.; 160–190° F.; and 180–210° F.) Reference to Serial Number will insure Replacement Parts being furnished to proper spec.

SUBCONTRACTORS PARTS LIST

Safety Control, Model No. 530

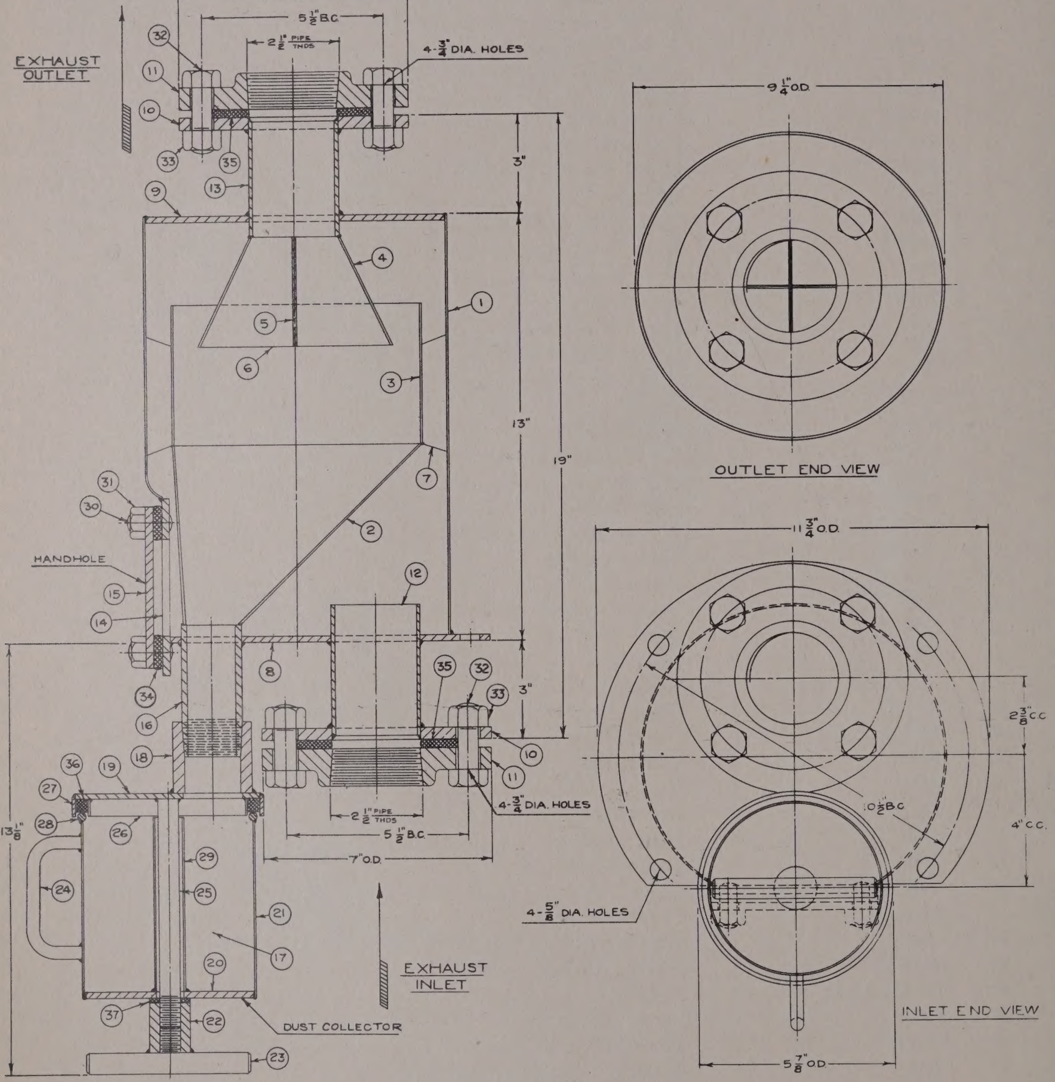
MANUFACTURED BY THE FULTON SYLPHON COMPANY, KNOXVILLE, TENNESSEE

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	1527	1	Pipe Plug, ⅛″ 27 STD.	$ .18
2	8378-C	1	Spring	.90
3	8388	1	Stop Sleeve	.09
4	8541	1	Lock Nut	.63
5	8368	1	Adj. Nut	.54
6	8371-C	1	Latch Spring	.90
7	8374	1	Pressure Stem Pin	.09
8	2536	1	Cotter Pin, 1/16″ x ⅜″	.04
9	8373	1	Fulcrum Pin	.72
10	1998	1	Cotter Pin, 1/16″ x ¾″	.04
11	9038	1	Stem Head	.36
12	429	1	Lock Nut	.27
13	5848	1	Set Screw	.09
14	8369	1	Cap Nut	1.35
15	9041	2	Upper Poppet Guide	.51
16	9043	1	Spring	1.08
17	9053	1	Gasket	.09
18	8382	1	Spring Housing	.63
19	8383	1	Temperature Spring	1.08
20	8380	1	Adj. Nut	.54
21	8540	1	Lock Nut	.63
22	8395	1	Thrust Stem Connector	.36
23	10542	1	Bulb Bushing	1.80
24	9054-T	1	Latch	.27
25	8389	2	Latch Lever Pivot Screw	.36
26	9037-T	1	Lever Bar	.45
27	9057	1	Body	7.56
28	11518	1	Grommet	.09
29	9040	1	Upper Poppet	.36
30	9044	1	Lower Poppet	.72
31	9056	1	Valve Body	4.50
32	9045	1	Plug	.99
33	829	8	Cup Screw	.04
34	696	12	Lock Washer	.04
35	1550	2	Cover Screw	.07
36	8397	1	Cover	.81
37	8394	2	Cover Screw	.06
38	6500	1	Machine Screw, Flat Head, No. 8-32 x ⅞″ Long	.04
39	9052-T	1	Spring Anchor	.36
40	107651-15rB	1	Bellows	——
A	92233	1	Valve Assembly	14.40
B	91960	1	Tube and Bulb Assembly	13.50
C	92255	1	Bushing and Spring Assembly	.90
D	92418	1	Pressure Element Assembly	5.40
E	92407	1	Sylphon Head and Stem Assembly	2.70

SUBCONTRACTORS PARTS LIST

Exhaust Silencer, Model SC, No. 5-2½"

MANUFACTURED BY MAXIM SILENCER COMPANY, HARTFORD, CONNECTICUT



7" O.D.
5 1/2" B.C.
2 1/2" PIPE THDS
4-3/4" DIA. HOLES
EXHAUST OUTLET
3"
13"
19"
9 1/4" O.D.
OUTLET END VIEW
HANDHOLE
11 3/4" O.D.
2 3/8" C.C.
10 1/2" B.C.
4" C.C.
4-5/8" DIA. HOLES
13 1/8"
2 1/2" PIPE THDS
5 1/2" B.C.
7" O.D.
4-3/4" DIA. HOLES
EXHAUST INLET
DUST COLLECTOR
INLET END VIEW
5 7/8" O.D.
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SUBCONTRACTORS PARTS LIST

Exhaust Silencer, Model SC, No. 5-2½″

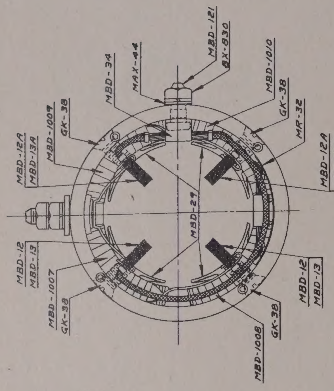
MANUFACTURED BY MAXIM SILENCER COMPANY, HARTFORD, CONNECTICUT

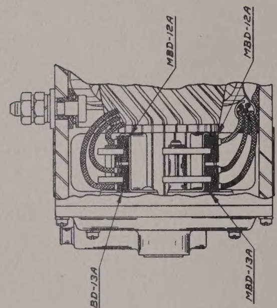
REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	NOTES
1		1	Steel Sheet	
2		1	Conical Separator	
3		1	Conical Separtor Tube	
4		1	Outlet Cone	
5		1	Vane	
6		2	Vane	
7		8	Spinner Blade	
8		1	Inlet Head	
9		1	Outlet Head	
10		2	Inlet and Outlet Flange	
11		2	Companion Flange	
12		1	Inlet Neck	
13		1	Outlet Neck	
14		1	Handhole Frame	
15		1	Handhole Cover	
16		1	Connection Pipe	
17		1	Spark Box Assembly	
18		1	Connection for No. 17	
19		1	Top for No. 17	
20		1	Base for No. 17	
21		1	Shell for No. 17	
22		1	Nut for No. 17	
23		1	Handle for No. 22	
24		1	Handle for No. 17	
25		1	Centering Rod for No. 17	
26		1	Inner Ring for No. 17	
27		1	Outer Ring for No. 17	
28		1	Compression Ring for No. 17	
29		1	Tubing for No. 17	
30		4	Stud for No. 14	
31		4	Hex. Nut for No. 30	
32		8	Hex. Bolt for No. 11⅝″ x 11 N.C. 3	
33		8	Hex. Nut for No. 32	
34		1	Gasket for No. 15 — ASB. Rope	
35		2	Gasket for No. 10 — ASB. Rope	
36		1	Gasket for No. 17 — ASB. Rope	
37		1	Gasket for No. 22 — ⅛″ Thick	

SUBCONTRACTORS PARTS LIST

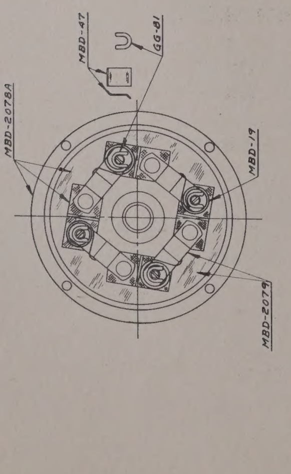
Starting Motor, Model MBD-4011

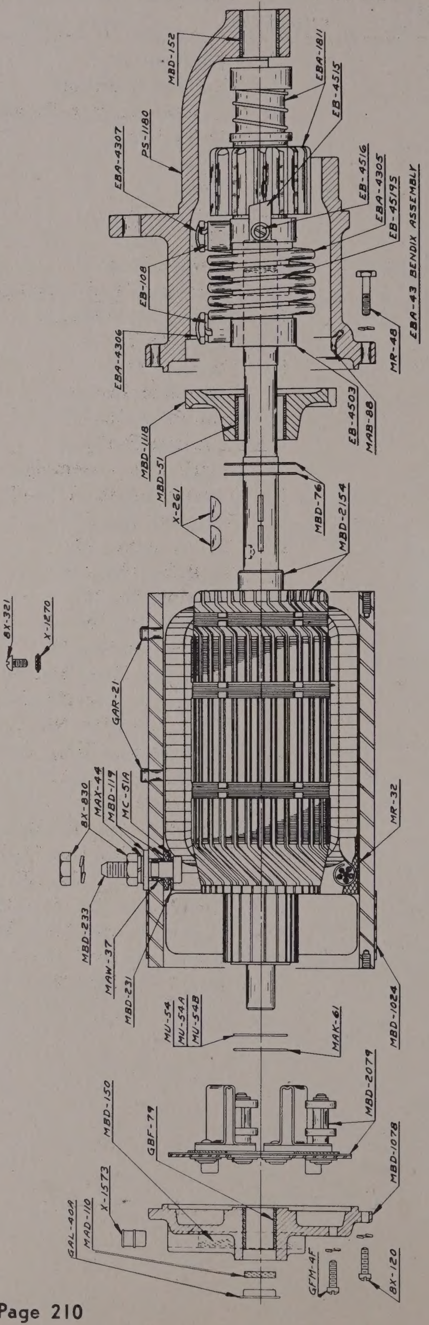
MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO


MBD-12A
MBD-13A
MBD-1009
GK-38
MBD-34
MAX-44
MBD-121
BX-830
MBD-1010
GK-38
MR-32
MBD-12A
MBD-13A
MBD-29
MBD-12
MBD-13
MBD-1007
GK-38
MBD-1008
GK-38
MBD-12
MBD-13


MBD-12A
MBD-12A
MBD-13A
MBD-13A

SECTION OF C.E. HEAD & FRAME SHOWING ASSEMBLY OF BRUSHES

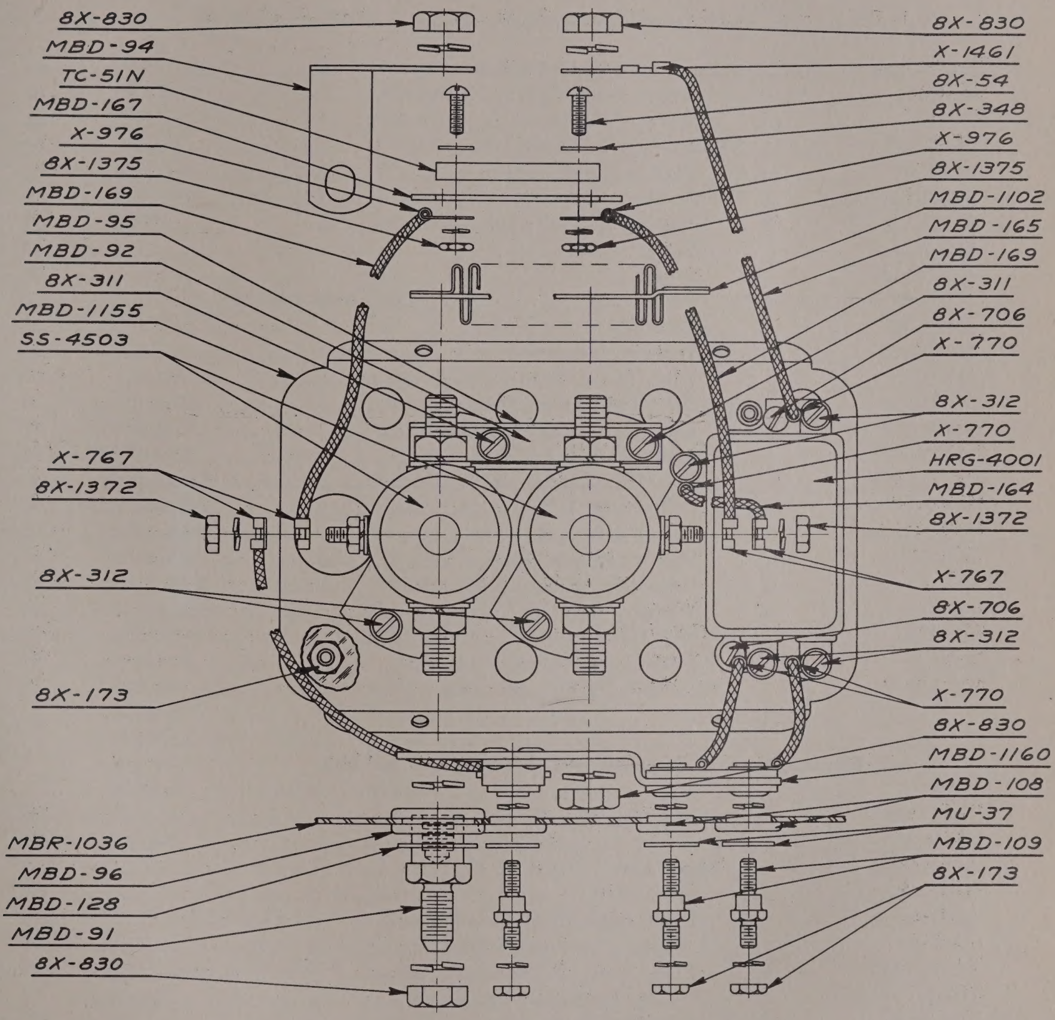

MBD-2078A
MBD-47
GG-81
MBD-19
MBD-2079


MBD-152
EBA-1811
EB-4515
PS-1180
EBA-4307
EB-4516
EBA-4305
EB-45195
EBA-43 BENDIX ASSEMBLY
EB-108
MR-48
EBA-4306
EB-4503
MAB-88
MBD-1118
MBD-51
X-261
MBD-76
MBD-2154
BX-321
X-1270
GAR-21
BX-830
MAX-44
MBD-119
MC-51A
MR-32
MBD-233
MAW-37
MBD-231
MU-54
MU-54A
MU-54B
MAK-61
MBD-1024
MBD-150
GBF-79
MBD-2079
MBD-1078
X-1573
MAD-110
GAL-40A
GFM-4F
BX-120

SUBCONTRACTORS PARTS LIST

Starting Motor, Model MBD-4011

MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO


8X-830
MBD-94
TC-51N
MBD-167
X-976
8X-1375
MBD-169
MBD-95
MBD-92
8X-311
MBD-1155
SS-4503
X-767
8X-1372
8X-312
8X-173
MBR-1036
MBD-96
MBD-128
MBD-91
8X-830
8X-830
X-1461
8X-54
8X-348
X-976
8X-1375
MBD-1102
MBD-165
MBD-169
8X-311
8X-706
X-770
8X-312
X-770
HRG-4001
MBD-164
8X-1372
X-767
8X-706
8X-312
X-770
8X-830
MBD-1160
MBD-108
MU-37
MBD-109
8X-173

SUBCONTRACTORS PARTS LIST

Starting Motor, Model MBD-4011

MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO

1. Frame and Field Assembly with Terminal Post and Parts Used With

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	MBD-2235	1	Frame and Field Assembly	——
	GAR-21	2	Dowel, Aligning	$ .01
	GK-38	8	Screw, Pole Piece	.01
	MAW-37	1	Bushing, Insulating	.03
	MAX-44	2	Washer, Steel, ⅜″	.01
	MBD-12	2	Brush	.75
	MBD-12A	2	Brush	.75
	MBD-13	2	Brush	.95
	MBD-13A	2	Brush	.95
	MBD-29	4	Pole Piece	.50
	MBD-34	1	Terminal	.15
	MBD-119	2	Washer, Insulating	.15
	MBD-121	1	Post, Term., ⅜-16 x 1⅛	1.00
	MBD-231	1	Connector, Term. Post	.35
	MBD-233	1	Post, Term., ⅜-16 x 1-13/16	.06
	MBD-1007	1	Coil, Field, U.L.	1.65
	MBD-1008	1	Coil, Field, L.L.	1.65
	MBD-1009	1	Coil, Field, U.R.	1.65
	MBD-1010	1	Coil, Field, L.R.	1.65
	MC-51A	1	Washer, Steel, ⅜″	.01
	MR-32	1	Insulation, Field Conn.	.01
	X-201	2	Washer, Lock, ⅜″	.05
	8X-830	2	Nut, Hex., ⅜-16	.05
	X-201	1	Washer, Lock, ⅜″	.05
	8X-830	1	Nut, Hex., ⅜-16	.05

2. Commutator End Head Assembly and Parts Used With

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	GAL-40A	1	Cover, Brg., Comm. End	.02
	MAD-110	1	Felt (¾ dia. x 5/32)	.02
	MBD-2078	1	Head Assy., Comm. End	17.50
	MBD-150	1	Wick, Felt	.12
	MBD-1078	1	Head Assy., Partial, C.E.	10.00
	GBF-79	1	Brg., Absorbent Bronze	.15
	MBD-2079	1	Plate Assy., Brush	6.50
	GG-81	4	Clip, Brush Holder	.01
	MBD-19	8	Spring, Brush	.07
	MBD-47	4	Spacer	.10
	8X-120	4	Screw, Fill. Sp. Hd., No. 10-32 x ⅝	.05
	X-196	4	Washer, Lock, No. 10	.05
	X-1573	1	Oiler, Press in Type, ⅜	.25
	8X-120	4	Screw, Fill. Hd., No. 10-32 x ⅝	.05
	X-544	4	Washer, Lock, No. 10	.05

SUBCONTRACTORS PARTS LIST

Starting Motor, Model MBD-4011

MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO

3. Armature Assembly and Parts Used With

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	MAK-61	1	Washer, Steel (.643 x 1 — 7/32 x .065)	$ .01
	MBD-76	2	Washer, Thrust	.15
	MBD-2154	1	Armature	40.00
	MU-54	*	Washer, Thrust (.645 x 1 — ¼ x 1/32)	.01
	MU-54A	*	Washer, Thrust (.645 x 1 — ¼ x 1/64)	.01
	MU-54B	*	Washer, Thrust (.645 x 1 — ¼ x 3/64)	.01
	X-261	2	Key, Woodruff, No. 6	.05

4. Miscellaneous Parts

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	EBA-43	1	Bendix Drive Assembly	17.50
	EB-108	2	Washer, Lock	.01
	EB-4503	1	Head, Driving	1.00
	EB-4515	1	Back Stop, Pinion	.40
	EB-4516	1	Screw, Back Stop, Pinion	.10
	EB-4519S	1	Sleeve, Compression	.50
	EBA-1811	1	S-A	10.50
	EBA-4305	1	Spring, Drive	3.60
	EBA-4306	1	Screw, Spring, Head	.25
	EBA-4307	1	Screw, Spring, Shaft	.20
	MBD-1024	1	Band, Head	.35
	MBD-1118	1	Brg. Assy., Intermediate	2.50
	MBD-51	1	Brg., Absorbent, Bronze	.45
	MR-48	8	Screw, Hex. Hd., No. 10 — 40 x ⅞	.07
	PS-1180	1	Housing Assy., Pinion	3.25
	MAB-88	1	Pin, Dowel	.01
	MBD-152	1	Brg., Absorbent Bronze	.80
	X-196	8	Washer, Lock, No. 10	.05
	8X-715	1	Screw, Rd. Hd., No. 10 — 32 x 1 — ¼	.05
	8X-794	1	Nut, Square, No. 10 — 32	.05

5. Starting Switch Assembly and Parts Used With

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	HRG-4001	1	Relay, Time Delay	3.50
	X-196	4	Washer, Lock No. 10	.05
	8X-312	4	Screw, Rd. Hd., No. 10 — 32 x ¼	.05
	MBD-91	1	Post, Terminal ⅜-16	.85
	MBD-92	1	Clamp	.12
	MBD-94	1	Connector, Terminal	1.00
	MBD-95	1	Insulation, Connector	.40
	MBD-96	1	Bushing, Insulating	.30
	MBD-108	3	Bushing, Rubber	.45

SUBCONTRACTORS PARTS LIST

Starting Motor, Model MBD-4011

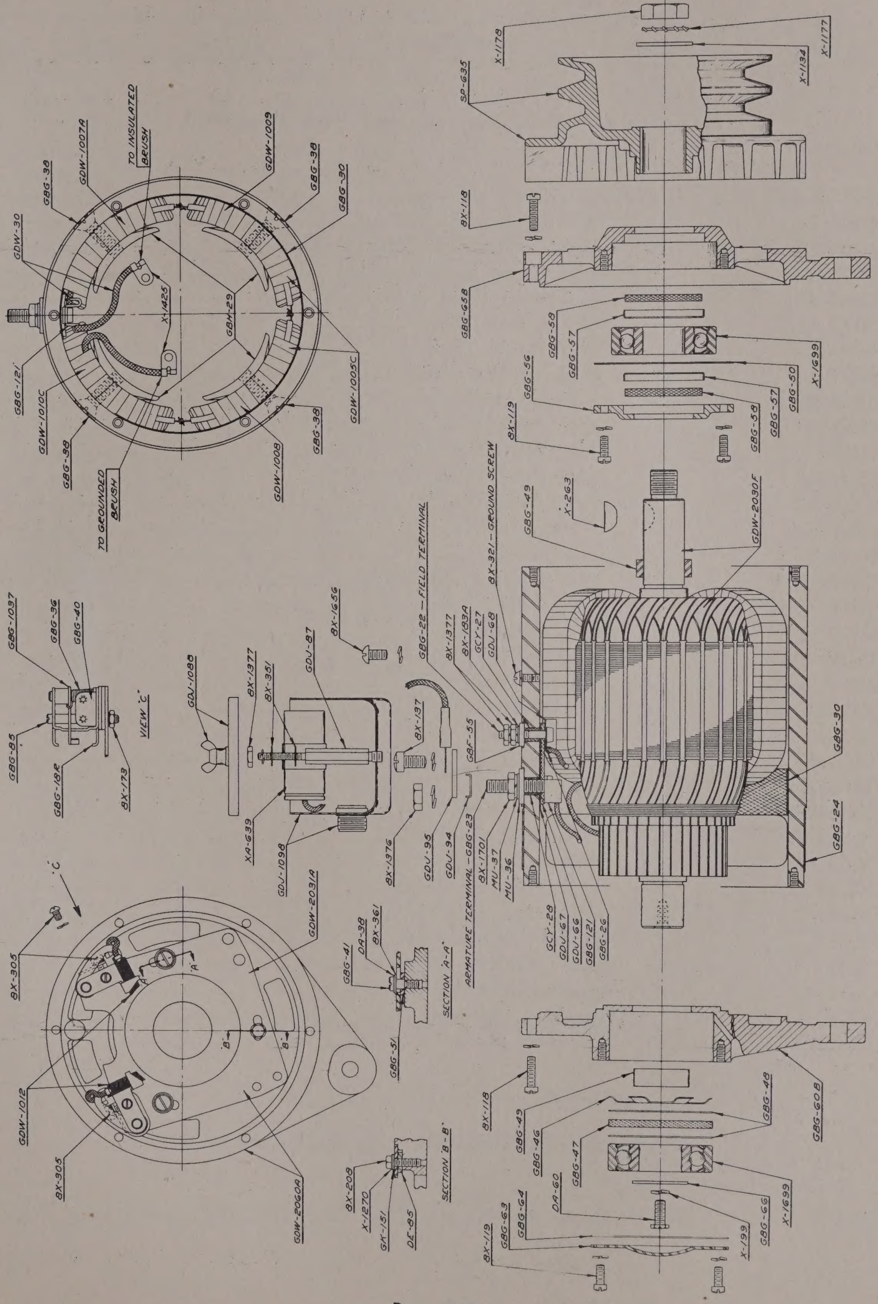
MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	MBD-109	3	Post, Terminal, No. 10 — 32	$ .15
	MBD-128	1	Washer, Steel, Plain	.10
	MBD-157	1	Lead Assy., 4½″	.05
	X-767	1	Terminal	.05
	MBD-159	2	Lead Assy., 2¼″	.05
	X-770	1	Terminal	.05
	MBD-164	1	Lead Assy., 1-15/16″	.07
	X-767	1	Terminal	.05
	X-770	1	Terminal	.05
	MBD-165	1	Lead Assy., 4½″	.10
	X-770	1	Terminal	.05
	X-1461	1	Terminal	.05
	MBD-167	1	Support, Resistor, Ins.	.25
	MBD-169	2	Lead Assy., 2¼″	.07
	X-767	1	Terminal	.05
	X-976	1	Terminal	.05
	MBD-1102	1	Resistance	5.00
	MBD-1155	1	Base, Switch, Mounting	.75
	MBD-1160	1	Connector, Assy.	1.80
	MBD-157	1	Lead, Assy., 4½″	.05
	X-767	1	Terminal	.05
	MBD-159	2	Lead Assy., 2¼″	.05
	X-770	1	Terminal	.05
	MBR-1036	1	Cover	1.50
	MU-37	3	Washer, Plain, 5/16″	.01
	SS-4503	2	Switch, Solenoid	10.00
	12X-196	1	Washer, Lock, No. 10	.05
	12X-201	2	Washer, Lock, ⅜″	.05
	8X-830	2	Nut, Hex., ⅜-16	.05
	8X-1372	1	Nut, Hex., No. 10 — 32	.05
	TC-51N	1	Resistance, Carbon, Marked 80	.15
	8X-54	2	Screw, Rd. Hd., No. 8 — 32 x ½	.05
	8X-173	5	Nut, Hex., No. 10 — 32	.05
	X-195	2	Washer, Lock, No. 8	.05
	X-196	12	Washer, Lock, No. 10	.05
	X-201	5	Washer, Lock, ⅜″	.05
	8X-311	2	Screw, Rd. Hd., No. 10 — 32 x ⅜	.05
	8X-312	2	Screw, Rd. Hd., No. 10 — 32 x ¼	.05
	8X-321	4	Screw, Rd. Hd., No. 10 — 32 x 5/16	.05
	8X-348	2	Washer, Special, No. 8	.05
	X-544	2	Washer, Lock, No. 10	.05
	8X-706	2	Screw, Bdg. Hd., No. 10 — 32 x 5/16	.05
	8X-830	4	Nut, Hex., ⅜-16	.05
	X-1270	4	Washer, Skpf., No. 10	.05
	8X-1375	2	Screw, Rd. Hd., No. 8 — 32	.05

SUBCONTRACTORS PARTS LIST

Charging Generator, Model GDW-4607A

MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO



X-1178
X-1177
SP-635
X-134
8X-118
GBG-658
GBG-58
GBG-57
X-1699
GBG-56
GBG-50
GBG-57
GBG-58
8X-119
X-263
GBG-49
GDW-2030F
GBG-30
GBG-24
GCY-28
GDU-67
GDU-66
GBG-121
GBG-26
8X-321 — GROUND SCREW
GBG-22 — FIELD TERMINAL
8X-1377
8X-1193A
GCY-27
GDJ-68
GBF-55
ARMATURE TERMINAL — GBG-23
8X-1701
MU-37
MU-36
GDU-95
GDU-94
8X-1376
8X-137
8X-1656
GDJ-87
8X-1377
8X-351
GDJ-1088
XA-639
GDJ-1098
GBG-1037
GBG-36
GBG-40
GBG-85
GBG-18R
8X-173
VIEW 'C'
GDW-30
GDW-1007A
TO INSULATED BRUSH
GDW-1009
GBG-38
GBG-30
GBG-121
X-1425
GBM-29
GDW-1005C
GDW-1010C
GBG-38
TO GROUNDED BRUSH
GDW-1008
GBG-38
'C'
8X-305
GDW-1012
8X-305
'A'
'B'
GDW-203IA
GDW-2060A
GBG-41
OA-38
8X-361
GBG-51
SECTION 'A-A'
8X-208
X-1270
GK-151
DE-85
SECTION 'B-B'
8X-118
GBG-49
GBG-46
GBG-47
OA-60
GBG-63
GBG-64
8X-119
GBG-48
GBG-608
X-1699
GBG-66
X-199

SUBCONTRACTORS PARTS LIST

Charging Generator, Model GDW-4607A

MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO

1. Frame and Field Assembly and Parts Used With

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	GDW-2040	1	Frame and Field Assy.	——
	GBF-55	1	Washer, Ins., Field Term. (13/64 x 9/16 x ⅛)	$ .02
	GBG-22	1	Post, Term., Field (No. 10-32)	.35
	GBG-23	1	Post, Term., Arm. (5/16-24)	.20
	GBG-30	1	Insulation, Field Connection	.05
	GBG-38	8	Screw, Pole Piece	.05
	GBH-29	4	Pole Piece	2.00
	GCY-27	1	Bushing, Ins., Field Term. (.190 x .328 x 5/16)	.08
	GCY-28	1	Bushing, Ins., Arm. Term. (.313 x .437 x 5/16)	.06
	GDJ-66	1	Ins., Term. Post (3/32 Thick)	.50
	GDJ-67	1	Ins., Term. Post (.015 Thick)	.10
	GDJ-68	1	Ins., Field Term. (Formed)	.03
	GDW-30	1	Lead Assembly	.25
	GBG-121	1	Terminal	.15
	X-1425	1	Terminal	.05
	GDW-1005C	1	Coil Assy., Field, Comp.	11.00
	GDW-1007A	1	Coil Assy., Field, U.R.	——
	GBG-26	1	Terminal	.04
	GDW-1008	1	Coil, Field, L.L.	2.75
	GDW-1009	1	Coil, Field, L.R.	2.75
	GDW-1010C	1	Coil Assy., Field, U.L.	2.75
	X-1425	1	Terminal	.05
	MU-36	1	Washer, Ins., Arm. Term. (11/32 x ⅞ x .125)	.05
	MU-37	1	Washer, Plain (21/64 x ⅝ x .042)	.01
	8X-183A	1	Washer, Plain, No. 10	.05
	X-196	1	Washer, Lock, No. 10	.05
	X-1014	1	Washer, Lock, 5/16″	.05
	8X-1377	1	Nut, Hex., No. 10-32	.05
	8X-1701	1	Nut, Hex., 5/16-24	.02
	X-196	2	Washer, Lock, No. 10	.05
	X-321	1	Screw, Rd. Hd., No. 10-32 x 5/16	.05
	X-1014	1	Washer, Lock, 5/16″	.05
	8X-1376	1	Nut, Hex., 5/16-24	.05
	8X-1377	1	Nut, Hex., No. 10-32	.05

2. Commutator End Head Assembly and Parts Used With

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	DA-60	1	Screw, Retaining, C.E. Sp. Brg. (Hex. Hd., ¼-28 x ⅝)	.05

SUBCONTRACTORS PARTS LIST

Charging Generator, Model GDW-4607A

MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	GBG-46	1	Washer, Sp. Spring	$ .35
	GBG-47	1	Washer, Felt (1-19/64 x 2-7/16 x 3/16)	.15
	GBG-48	2	Retainer, Felt Washer (1.531 x 2.436 x .032)	.04
	GBG-63	1	Cover, Comm. End	.25
	GBG-64	1	Gasket, Comm. End Cover	.15
	GBG-66	1	Washer, Brg. Retaining (.254 x 1 — 5/16 x .065)	.15
	GDW-2060A	1	Head Assy., Comm. End	——
	DA-38	2	Washer, Spring	.08
	DE-85	1	Washer, Plain (.193 x ½ x .095)	.01
	GBG-41	2	Screw, Attaching, Brush Plate	.10
	GBG-51	2	Washer, Plain (.265 x ½ x .095)	.02
	GBG-60B	1	Head	——
	GDW-1012	2	Brush	.60
	GDW-2031A	1	Plate Assy., Brush	2.90
	GBG-18R	2	Holder, Brush	.20
	GBG-36	2	Spring, Brush	.10
	GBG-40	2	Term., Brush Holder	.06
	GBG-85	2	Stud, Brush Holder	.15
	GBG-1037	2	Arm, Brush	.50
	8X-173	2	Nut, Hex., No. 10-32	.05
	X-196	2	Washer, Lock, No. 10	.05
	GK-151	1	Washer, Plain (.197 x ⅜ x .032)	.01
	X-195	2	Washer, Lock, No. 8	.05
	8X-208	1	Screw, Hex. Hd., No. 10-32 x 9/16	.05
	8X-305	2	Screw, Rd. Hd., No. 8-32 x ¼	.05
	8X-361	2	Washer, Plain, ¼	.05
	X-1270	1	Washer, Skpf., No. 10	.05
	8X-118	6	Screw, Fill. Hd., No. 10-32 x ¾	.05
	8X-119	4	Screw, Fill. Hd., No. 10-32 x ½	.05
	X-195	2	Washer, Lock, No. 8	.05
	X-196	10	Washer, Lock, No. 10	.05
	X-199	1	Washer, Lock, ¼"	.05
	8X-305	2	Screw, Rd. Hd., No. 8-32 x ¼	.05
	X-1699	1	1 Brg., Ball, Shielded, S.A.E. No. 305	4.50

3. Armature Assembly and Parts Used With

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	GBG-49	2	Spacer, Arm. Shaft (.985 x 1.300 x .439)	.40
	GDW-2030F	1	Armature	45.00
	SP-635	1	Pulley, Drive	9.85
	X-263	1	Key, Woodruff, No. 8	.05
	X-1134	1	Washer, Plain, ⅝"	.05
	X-1177	1	Washer, Skpf., ⅝"	.07
	X-1178	1	Nut, Hex., ⅝-18	.06

SUBCONTRACTORS PARTS LIST

Charging Generator, Model GDW-4607A

MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO

4. Drive End Head Assembly and Parts Used With

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	GBG-1065B	1	Head Assy., Drive End	$14.75
	GBG-50	1	Gasket, Bearing Retainer	.08
	GBG-57	1	Retainer, Felt Washer, Outer	.06
	GBG-58	1	Washer, Felt, Outer (1-19/64 x 1 — 13/16 x 3/16)	.06
	GBG-65	1	Head	8.50
	GBG-1056	1	Retainer Assy., Bearing	1.00
	GBG-56	1	Retainer, Bearing	.80
	GBG-57	1	Retainer, Felt Washer	.06
	GBG-58	1	Washer, Felt (1-19/64 x 1 — 13/16 x 3/16)	.06
	8X-119	4	Screw, Fill. Hd., No. 10-32 x ½	.05
	X-196	4	Washer, Lock No. 10	.05
	X-1699	1	Bearing, Ball, Shielded, S.A.E. No. 305	4.50
	8X-118	6	Screw, Fill. Hd., No. 10-32 x ¾	.05
	X-544	6	Washer, Lock, No. 10	.05

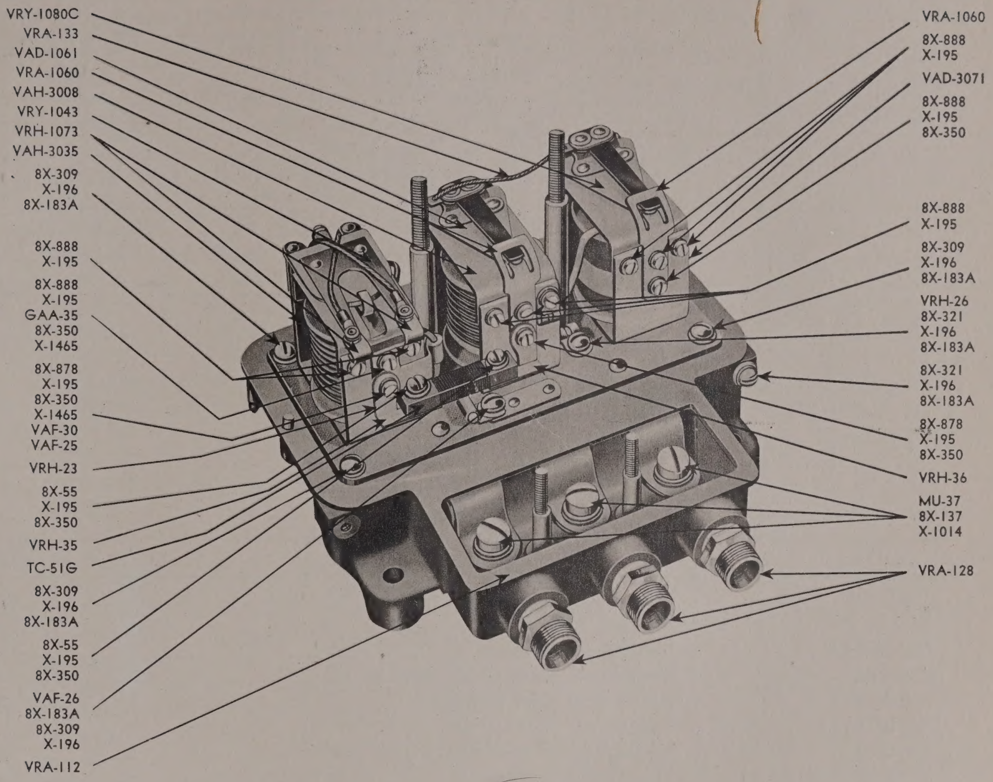
5. Miscellaneous Parts

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	GBG-24	1	Band, Head	.35
	GDJ-87	1	Stud, Cover Shield	.25
	GDJ-94	1	Plate, Locking	.02
	GDJ-95	1	Connector	.08
	GDJ-1088	1	Cover, Shield	.30
	GDJ-1098	1	Shield, Terminal	1.50
	X-137	1	Screw, Fill. Hd., 5/16-24 x ½	.05
	X-196	1	Washer, Lock, No. 10	.05
	X-199	2	Washer, Lock, ¼″	.05
	X-203	1	Washer, Lock, 5/16″	.05
	8X-351	2	Washer, Steel, No. 10	.05
	8X-715	1	Screw, Rd. Hd., No. 10-32 x 1¼	.05
	8X-794	1	Nut, Square, No. 10-32	.05
	8X-1377	1	Nut, Hex., No. 10-32	.05
	8X-1656	2	Screw, Rd. Hd., ¼-20 x 7/16	.05
	XA-639	1	Condenser	1.75

SUBCONTRACTORS PARTS LIST

Current-Voltage Regulator, Model VAH-4001A

MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO


VRY-1080C
VRA-133
VAD-1061
VRA-1060
VAH-3008
VRY-1043
VRH-1073
VAH-3035
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X-196
8X-183A
8X-888
X-195
8X-888
X-195
GAA-35
8X-350
X-1465
8X-878
X-195
8X-350
X-1465
VAF-30
VAF-25
VRH-23
8X-55
X-195
8X-350
VRH-35
TC-51G
8X-309
X-196
8X-183A
8X-55
X-195
8X-350
VAF-26
8X-183A
8X-309
X-196
VRA-112
VRA-1060
8X-888
X-195
VAD-3071
8X-888
X-195
8X-350
8X-888
X-195
8X-309
X-196
8X-183A
VRH-26
8X-321
X-196
8X-183A
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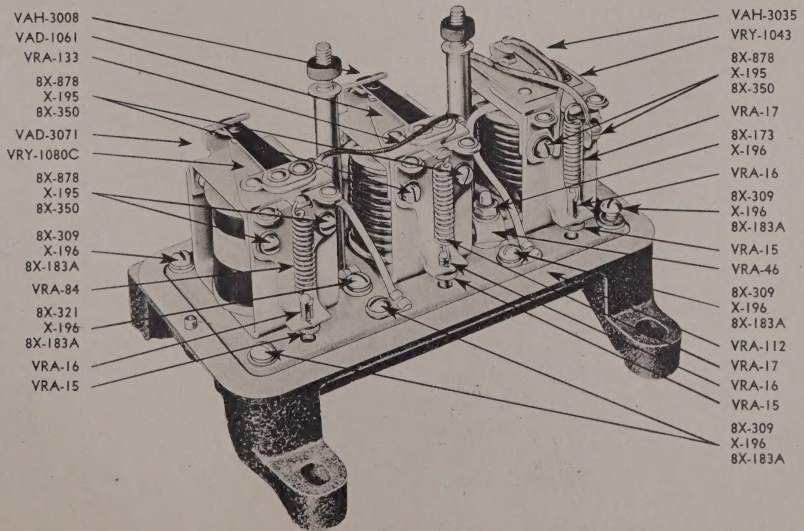
MU-37
8X-137
X-1014
VRA-128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VRA-84
8X-321
X-196
8X-183A
VRA-16
VRA-15
VAH-3035
VRY-1043
8X-878
X-195
8X-350
VRA-17
8X-173
X-196
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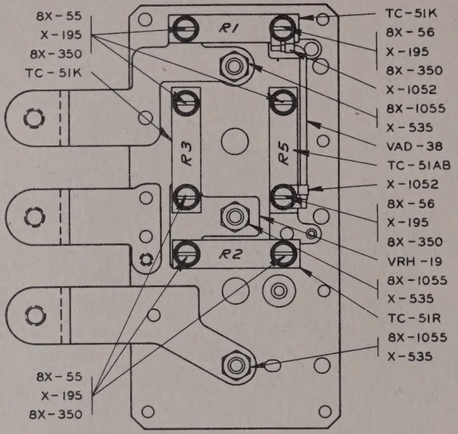
8X-183A
VRA-112
VRA-17
VRA-16
VRA-15
8X-309
X-196
8X-183A

SUBCONTRACTORS PARTS LIST

Current-Voltage Regulator, Model VAH-4001A

MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO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TC-51K
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VAD-38
TC-51AB
X-1052
8X-56
X-195
8X-350
VRH-19
8X-1055
X-535
TC-51R
8X-1055
X-535
8X-55
X-195
8X-350
R1
R3
R5
R2

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	GAG-138	1	Seal, Lead and Wire	$0.95
	MU-37	3	Washer, Plain (5/16)	.01
	TC-51AB	1	Resistance, Carbon	——
	TC-51G	1	Resistance, Carbon Marked 1.4	.15
	TC-51K	1	Resistance, Carbon Marked 135	.15
	TC-51M	1	Resistance, Carbon Marked 60	.15
	TC-51R	1	Resistance, Carbon Marked 11	.15
	VAD-38	1	Lead Assembly	——
	X-1052	2	Terminal	.05
	VAD-3071	1	Coil Assy., V.R.	——
	VRA-15	1	Nut, Adjusting	.20
	VRA-16	1	Screw, Adjusting	.70
	VRA-84	1	Spring, Armature	.25
	VRA-1060	1	Bracket, Adjusting	.15
	VRY-1080C	1	Armature	1.60
	X-195	6	Washer, Lock, No. 8	.05
	8X-350	4	Washer, Plain, No. 8	.05
	8X-878	2	Screw, Fill. Hd., No. 8-32 x 7/16	.05
	8X-888	4	Screw, Fill. Hd., No. 8-32 x 5/16	.05
	VAF-26	1	Connector	——
	VAH-3008	1	Coil Assy., C.R.	4.80
	VAD-1061	1	Armature, Regulator	1.50
	VRA-15	1	Nut, Adjusting	.20
	VRA-16	1	Screw, Adjusting	.70
	VRA-17	1	Spring, Armature	.15
	VRA-1060	1	Bracket, Adjusting	.15
	VRH-36	1	Bracket, Resistor	.05

SUBCONTRACTORS PARTS LIST

Current-Voltage Regulator, Model VAH-4001A

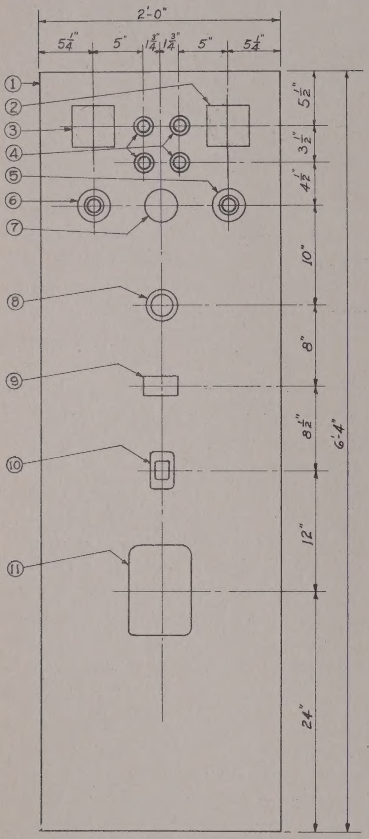
MANUFACTURED BY ELECTRIC AUTO-LITE COMPANY, TOLEDO, OHIO

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	8X-1722	1	Nut, Hex., No. 10-48	$ .03
	X-195	6	Washer, Lock, No. 8	.05
	8X-350	4	Washer, Plain, No. 8	.05
	X-537	1	Washer, Lock, No. 10	.05
	8X-878	3	Screw, Fill. Hd., No. 8-32 x 7/16	.05
	8X-888	3	Screw, Fill. Hd., No. 8-32 x 5/16	.05
	VAH-3035	1	Coil Assembly, C.B.	7.45
	GAA-35	1	Washer, Insulating	.01
	VAF-25	1	Washer, Insulating	.03
	VAF-30	1	Bushing, Insulating	—
	VRA-15	1	Nut, Adjusting	.20
	VRA-16	1	Screw, Adjusting	.70
	VRA-17	1	Spring, Armature	.15
	VRH-23	1	Insulation	.03
	VRH-35	1	Bracket, Resistor	.10
	VRH-1073	1	Contact and Bracket, Stationary	.30
	VRY-1043	1	Armature, C.B.	.75
	8X-1722	1	Nut, Hex., No. 10-48	.03
	X-195	6	Washer, Lock, No. 8	.05
	8X-350	4	Washer, Plain, No. 8	.05
	X-537	1	Washer, Lock, No. 10	.05
	8X-878	3	Screw, Fill. Hd., No. 8-32 x 7/16	.05
	8X-888	3	Screw, Fill. Hd., No. 8-32 x 5/16	.05
	X-1465	2	Washer, Insulating	.05
	VRA-46	1	Connector, Series Coil	.10
	VRA-51	1	Gasket, Terminal	.05
	VRA-52	1	Insulator, Terminal	.25
	VRA-112	1	Gasket, Cover	1.65
	VRA-128	3	Coupling	—
	VRA-133	1	Lead, V.R. Armature to C.R. Armature	.05
	VRA-1111	1	Cover and Nut	2.75
	VRA-1121	1	Cover and Nut, Terminal	.45
	VRH-19	1	Bracket, Resistor	.25
	VRH-26	1	Lead	.10
	8X-55	8	Screw, Rd. Hd., No. 8-32 x 3/8	.05
	8X-56	2	Screw, Rd. Hd., No. 8-32 x 7/16	.05
	8X-137	3	Screw, Fill. Hd., 5/16-24 x 1/2	.05
	8X-173	1	Nut, Hex., No. 10-32	.05
	8X-183A	10	Washer, Plain, No. 10	.05
	X-195	10	Washer, Lock, No. 8	.05
	X-196	11	Washer, Lock, No. 10	.05
	8X-309	7	Screw, Rd. Hd., No. 10-32 x 1/2	.05
	8X-321	3	Screw, Rd. Hd., No. 10-32 x 5/16	.05
	8X-350	10	Washer, Plain, No. 8	.05
	X-535	3	Washer, Lock, 1/4"	.05
	X-1014	3	Washer, Lock, 5/16"	.05
	8X-1055	3	Nut, Hex., 1/4-28	.05

SUBCONTRACTORS PARTS LIST

Switchboard

MANUFACTURED BY KIRKHOF ELECTRIC COMPANY, GRAND RAPIDS, MICHIGAN



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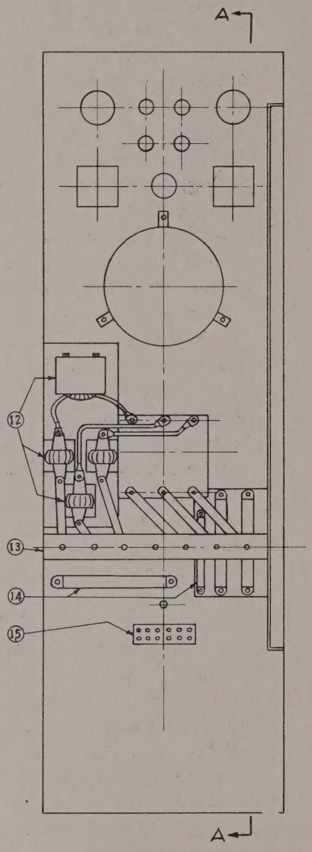
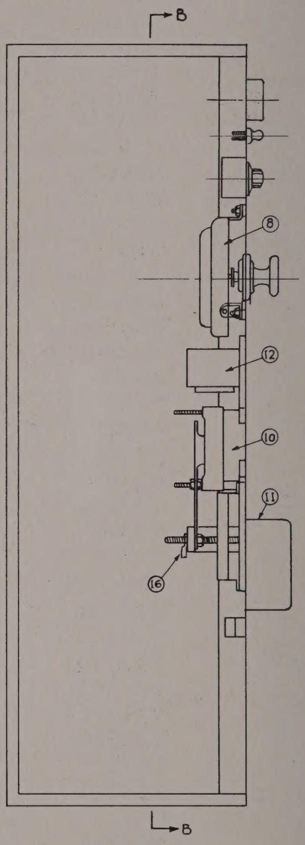
12"
24"
6'-4"

FRONT ELEVATION



REAR ELEVATION
SECTION "B-B"



SECTION "A-A"

SUBCONTRACTORS PARTS LIST

Switchboard

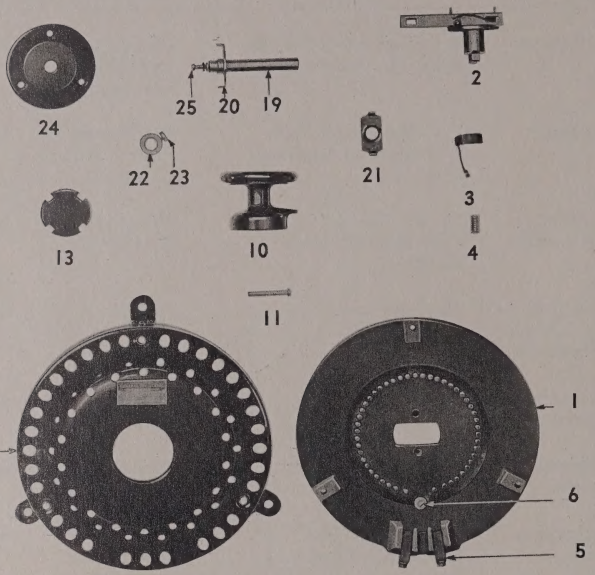
MANUFACTURED BY KIRKHOF ELECTRIC COMPANY, GRAND RAPIDS, MICHIGAN

REF. No.	QUANTITY	PART NAME	DESCRIPTION	MANUFACTURER	IDENTIFICATION	PRICE EACH
2	1	Voltmeter	A.C.Range 0-300 Volt, square moulded case	Burlington Instrument Company	Model 142A	$15.95
3	1	Ammeter	A.C. Range 0-5 scale 0-75 square moulded case	Burlington Instrument Company	Model 142C	8.20
4	4	Synchronizing Lamps	7½ W, 120 V. clear medium base Mazda	Westinghouse Electric Co.	No. S-11	.10
	4	Synchronizing Lamps Receptacle	Medium base	Bryant	Cat. No. 4117	.56
5	1	Voltmeter Switch	Three-phase	Kirkhof Electric Co.	K210	15.00
6	1	Ammeter Switch	Three independent circuit	Kirkhof Electric Co.	K200	13.00
7	1	Frequency Meter	A.C. range, 58 to 62 cycles, round flush mounting	J.B.T. Instrument Company	Model 33-F	39.00
8	1	Field Rheostat	Exciter field	General Electric Company	Type CR 8000-B1 2240000 C-256	13.00
10	1	Circuit Breaker	70 Amp. 3-pole 2500 A.C.	Westinghouse Electric Co.	Type AB Style No. 999-137	83.00
11	1	Voltage Regulator	208-240 volts, 60 cycles	Burlington Instrument Co.	Type GL-1	65.00
12	3	Current Transformers	75/5 600 volt, 10 VA, 25-60 cycle	Standard Transformer Co.	Type CTS	8.90
13	1	Connection Block	Transite	Kirkhof Electric Co.	No. K-120	1.50
15	1	Terminal Block	6 point, 120 volt	Insulation Mfg. Co.	Type H-6	1.25
16	8	Solderless Lugs	125 Amp. ⅜″ hole	Ilsco Copper Tube Products, Inc.	Cat. SLU-125	.12
	2	Condensers	½ Mfd.	Echlin Mfg. Company	No. AL-57	.60

SUBCONTRACTORS PARTS LIST

Switchboard Rheostat, No. CR8000-B1, Cat. No. 2240000G256

MANUFACTURED BY GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK



REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	3127801G256	1	Resistance Plate	$10.00
2	2284185G1	1	Contact arm, complete	2.40
3	2298005	2	Contact shoe and shunt	.40
4	2293420	2	Spring for contact shoe and shunt	.10
5	2229361P5	3	Connection strip for resistance plate	5.50/C
6	2224952	1	Stop post for contact arm	6.00/C
7	2224177G2	1	Front Cover	2.80
10	3676611	1	Handwheel	1.60
11	32X673	1	Screw fastening handwheel to contact arm	2.00/C

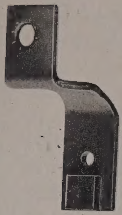
Auxiliary Operating Mechanism

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
—	2224183G1	1	Operating mechanism for back of board mounting	2.00
19	2239967	1	Shaft	.40
20	2224711	1	Coupling wheel (front of panel)	.40
21	2224718	1	Coupling wheel (back of panel)	.40
13	1470993	1	Coupling disc	.30
22	2247631	1	Collar for shaft	.20
23	46X801	1	Set screw for collar	3.00/C
24	2224720	1	Retaining plate for shaft	.40

SUBCONTRACTORS PARTS LIST

Switchboard Circuit Breaker, Model AB

MANUFACTURED BY WESTINGHOUSE ELEC. & MFG. CO., EAST PITTSBURGH, PA.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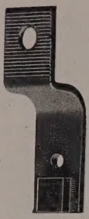
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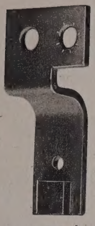
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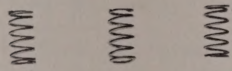
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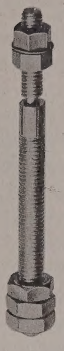
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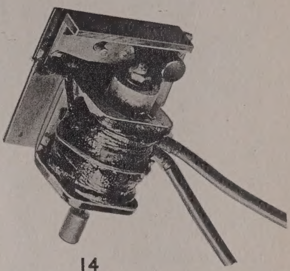
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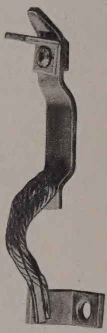
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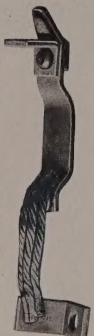
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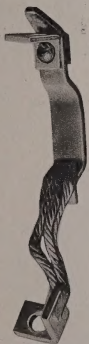
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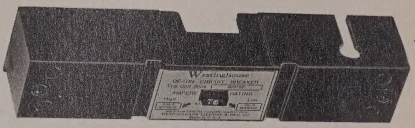

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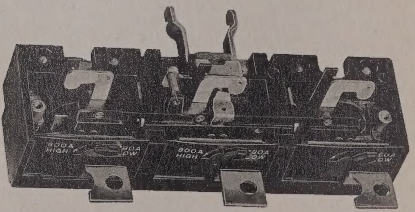
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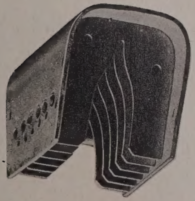
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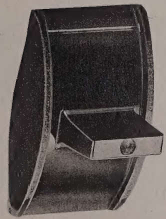
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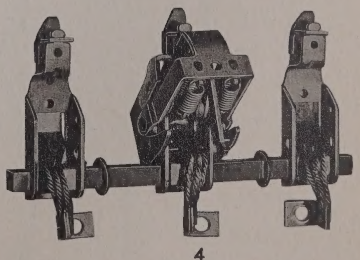
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SUBCONTRACTORS PARTS LIST

Switchboard Circuit Breaker, Model AB

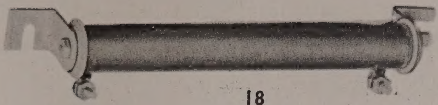
MANUFACTURED BY WESTINGHOUSE ELEC. & MFG. CO., EAST PITTSBURGH, PA.

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
	999-137	1	Breaker Complete	$83.00
1	999-197	1	Trip Unit Complete	15.00
2	894-048	1	Trip Unit Cover	1.00
3	1072244	1	Breaker Frame Complete without Trip Unit	28.00
4	1072443	1	Three-pole Moving Contact Assembly	25.00
5	1072445	1	Moving Contact and Shunt — Left-Hand	3.00
5	1072498	1	Moving Contact and Shunt — Center	3.00
5	1072498	1	Moving Contact and Shunt — Right-Hand	3.00
6	1072255	3	Moving Contact Spring	.10
9	1020604	1	Moulded Handle	1.50
10	894176	1	Stationary Conductor With Arcing Contact — Left-Hand	2.50
10	894177	1	Stationary Conductor With Arcing Contact — Center	2.50
10	894175	1	Stationary Conductor With Arcing Contact — Right-Hand	2.50
11	1072446	3	Arc Chamber	1.60
12	1072324	1	Cover Complete	5.50
13	807714	6	Rear Connection Studs	1.00
14	1222364	1	Shunt Trip Attachment Complete	34.00

SUBCONTRACTORS PARTS LIST

Switchboard Voltage Regulator, Model GL-1

MANUFACTURED BY BURLINGTON INSTRUMENT COMPANY, BURLINGTON, IOWA



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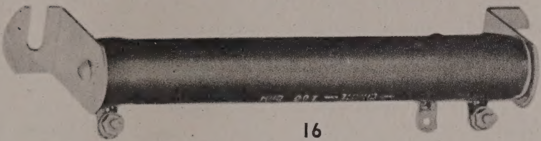

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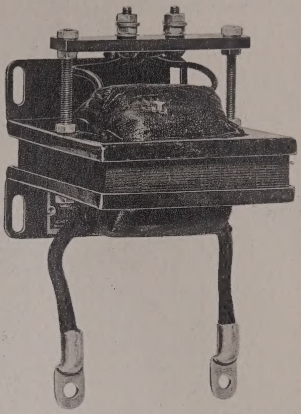

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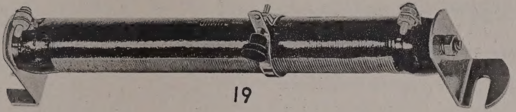

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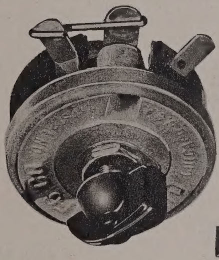

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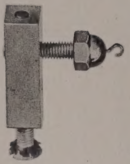

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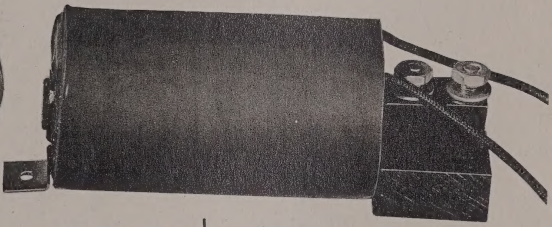

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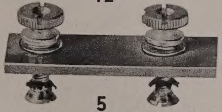

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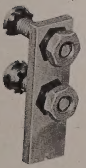

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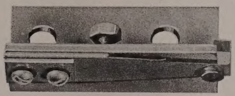

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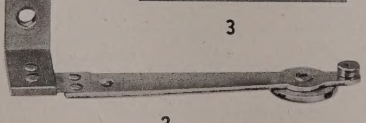

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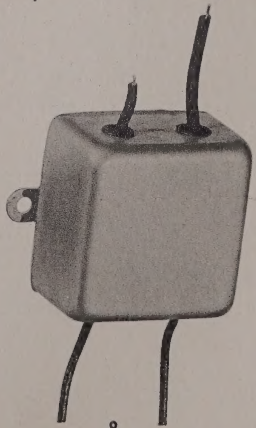

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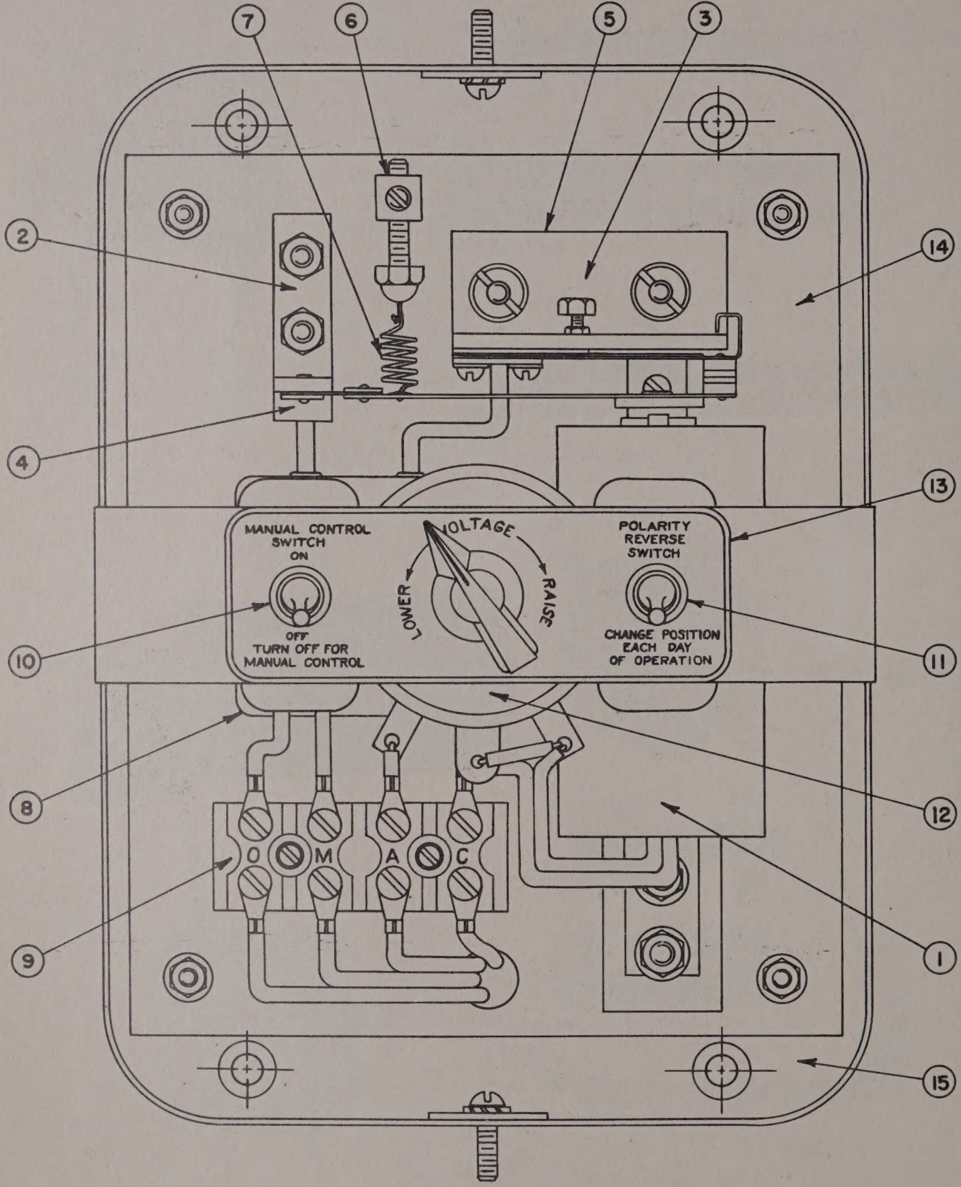
SUBCONTRACTORS PARTS LIST

Switchboard Voltage Regulator, Model GL-1

MANUFACTURED BY BURLINGTON INSTRUMENT COMPANY, BURLINGTON, IOWA



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MANUAL CONTROL SWITCH
ON
OFF
TURN OFF FOR MANUAL CONTROL
VOLTAGE
LOWER
RAISE
POLARITY REVERSE SWITCH
CHANGE POSITION EACH DAY OF OPERATION
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12
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VOLTAGE REGULATOR

SUBCONTRACTORS PARTS LIST

Switchboard Voltage Regulator, Model GL-1

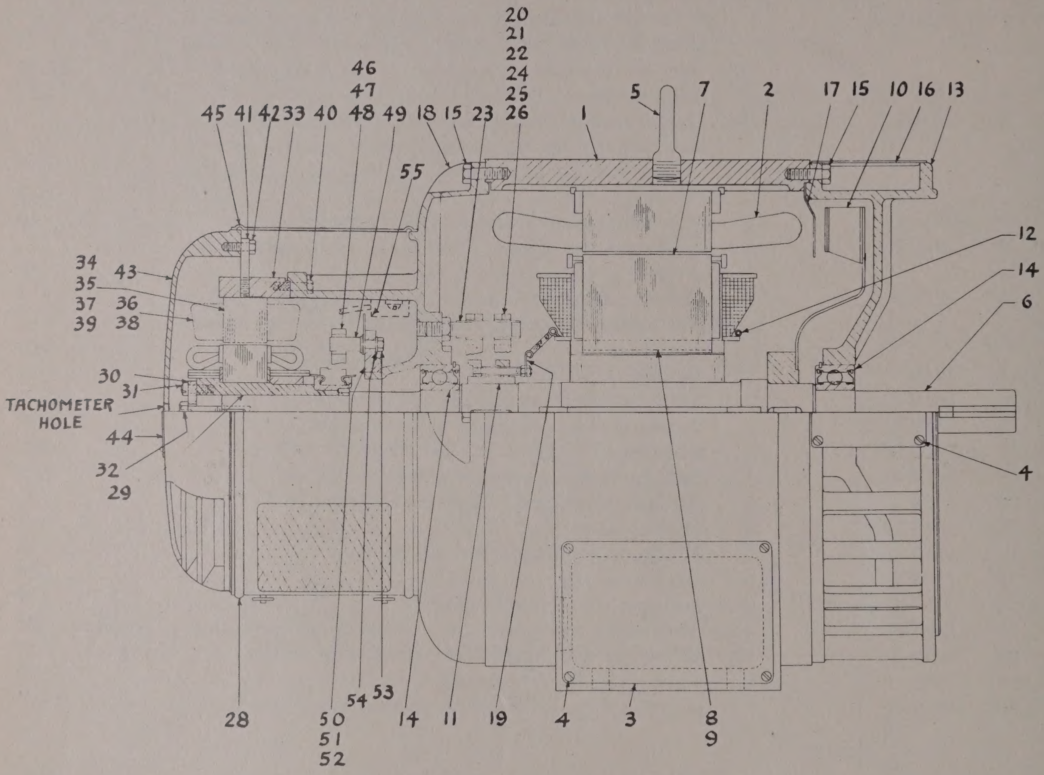
MANUFACTURED BY BURLINGTON INSTRUMENT COMPANY, BURLINGTON, IOWA

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	PRICE EACH
1	208VL-A	1	Potential coil assembly (Consisting of coil, lamination stack, bumper, coil bracket, coil spacer and screws, nuts, and washers required for mounting assembly)	$6.50
2	218VL	1	Vibrator assembly (with lower contact)	2.25
3	249VL	1	Upper contact bracket assembly (consisting of upper leaf contact, spring back, contact washer, contact spacer, tension adjustment, angle bracket, and leaf contact screws)	4.00
4	217VL	1	Vibrator spacer (complete with mounting screws)	.40
5	242VL	1	Angle bracket spacer (complete with mounting screws)	.50
6	227VL	1	Voltage adjustment screw assembly (consisting of post, mounting screw, adjustment screw, set screw, and slug)	1.00
7	224V	1	Voltage adjustment spring	.10
8	266V	1	Filter assembly (with leads and mounting screws)	3.50
9	286VL	1	Terminal block assembly (with mounting screws)	.85
10	282VL	1	Regulator control switch assembly (with leads)	1.25
11	284VL	1	Polarity reverse switch assembly (with leads)	1.25
12	677V	1	Voltage adjustment rheostat (with knob)	2.50
13	293VL	1	Control plate	.25
14	276VL	1	Ebony panel (with mounting screws)	4.00
15	292VL	1	Regulator case	6.00
16	7V	2	100 ohm 160 watt series resistor (for 208-240 V.)	2.50
17	CM-24	4	Mounting screws, nuts and washers (advise thickness of panel)	.25
18	0772	1	25 ohm 75 watt exciter current limiting resistor	2.00
19	14V	1	5 ohm cross current resistor	2.50
20	8419	1	60/5 125 V.A., 50/60 cycles, current transformer	14.50

SUBCONTRACTORS PARTS LIST

Synchronous Generator, Model 12G342

MANUFACTURED BY THE GENERAL ELECTRIC CO., FORT WAYNE, IND.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TACHOMETER HOLE
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ITEM NUMBER	PART NAME	DESCRIPTION	IDENTIFICATION	EACH PRICE
1	Generator	Type ATI Frame — 944-E	Model No. 12G565..........	——
2	Stator, Complete		Cat. No. 8101451AKG1	$628.00
3	Cover, Stator Frame		Cat. No. 5867891P1	.60
4	Screw, Stator Frame Cover	1/4″ 20 Rd. Hd. x 1/2″ lg.	Cat. No. 167816	.75/C
5	Eye Bolt	Std. Stl. 1 1/4″-7	Cat. No. 13363	4.00
6	Rotor Assy. Complete		Cat. No. 8134768G1	850.00
7	Coil and Pole Rotor Assy.		Cat. No. 8103572AGG1 ..	65.00
8	Pole Key, Rotor Steel		Cat. No. 214X12	1.00
9	Shim, Pole Key	.025″ x 1/2″ x 6 7/8″	....	——
10	Fan		Cat. No. 5881025G1	48.00
11	Collector		Cat. No. 5822376G2	48.00

SUBCONTRACTORS PARTS LIST

Synchronous Generator, Model 12G342

MANUFACTURED BY THE GENERAL ELECTRIC CO., FORT WAYNE, IND.

ITEM NUMBER	PART NAME	DESCRIPTION	IDENTIFICATION	EACH PRICE
12	Connection, Coil-to-Coil	Copper wire, No. 6 (.162″), 4¼″ lg.		——
13	Bearing Brckt. and Adaptor		Cat. No. 5813817P1	$ 80.00
14	Bearing, Ball	Norma-Hoffman No. 43610-5	Cat. No. (GE) 96x602	13.50
15	Cap Screw	½″-13, Hex. Hd. 1½″ lg.	Cat. No. 9887	5.00/C
16	Cover, Brg. Brckt., and Adaptor		Cat. No. 5890631P2	5.50
17	Air Baffle		Cat. No. 8103169	8.00
18	Brg. Brckt., Exciter End		Cat. No. 5848474ABP1	96.00
19	Terminal, Collector Rings		Cat. No. 417620	.20
20	Brush Assy.		Cat. No. 5804490	63.50/C
21	Brush-holder Assy. Complete		Cat. No. 5844427ABG1	3.80
23	Brush-holder Stud and Insulation		Cat. No. 5823467ABG4	6.50
24	Ferrule Brush-holder Stud		Cat. No. 2435212	.20
25	Spring		Cat. No. 243928	.25
26	Lever Assy.		Cat. No. 1846460G1	.40
27	Jam-nut, Brush-holder Stud	Hex., ⅝″-11	Cat. No. 152503	24.00/C
28	Exciter		Model No. 17G392	——
29	Armature, Complete Exciter		Cat. No. 8134741G1	280.00
30	Plate, Armature		Cat. No. 5890522	4.00
31	Screw	⅜″-16, Fil. Hd. 1″ lg.	Cat. No. 9831	6.00/C
32	Capscrew, Armature to Shaft		Cat. No. 5867872P7	24.00/C
33	Magnet Frame Assy. Complete		Cat. No. 214X92	48.00
34	Main Pole		Cat. No. 1792901ACG1	3.00
35	Shim, Main Pole		Cat. No. 5874086	.45
36	Coil, Main Field		Cat. No. 8134358ABG1	12.00
37	Capscrew	½″-13, Hex. Hd. 1¾″ lg.	Cat. No. 5150	5.00/C
38	Pad-field Coil		Cat. No. 5874085	.20
39	Connection Clip		Cat. No. 1743528G1	1.00
40	Capscrew	⅜″-16, Hex. Hd. 1¼″ lg.	Cat. No. 10299	3.00/C
41	Rod End		Cat. No. 5838561	3.00/C
42	Capscrew	⅜″-16, Hex. Hd. 1″ lg.	Cat. No. 308	2.50/C
43	End Shield		Cat. No. 5843918ABP2	16.00
44	GE Monogram, End Shield		Cat. No. NP-3706A	1.50
45	Cover, Exciter		Cat. No. 5848462ADG6	28.00
46	Brush Assy.		Cat. No. 5804446	46.65/C
47	Spring		Cat. No. 3794709	.50
48	Brush Holder, Complete		Cat. No. 4813380G13	3.40
49	Brush-holder Stud with Nut and Washer		Cat. No. 5822520G2	2.00
50	Yoke, Brush		Cat. No. 5822519P1	8.00
51	Screw, Brush Yoke	5/16″-18, Rd. Hd. 4″ lg.	Cat. No. 284X63	8.50/C
52	Nut, Brush Yoke, Screw	5/16″-18, Hex.	Cat. No. 47346	1.50/C
53	Jam-nut, Brush-holder Stud	⅜″-16, Hex.	Cat. No. 47347	5.50/C
54	Washer, Brush-holder Stud	¾″ OD, 13/32″ ID .062″ thk.	Cat. No. 414729	.40/C
55	Capacitor, Exciter	.25 microfarad	Cat. No. IGB-1025J	1.10

SECTION III

SPARE PARTS LIST

SPARE PARTS LIST

The following spare parts were furnished with each engine-generator set

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	NOTES
			1. Starting Motor Spares	
	MBD-12	2 sets	Brushes	
	MBD-12-A	2 sets	Brushes	
	MBD-13	2 sets	Brushes	
	MBD-13-A	2 sets	Brushes	
	MBD-2079	1 set	Brush Holder Assembly	
			2. Charging Generator Spares	
	GDW-1012	2 sets	Main Brushes	
	GDW-2031-A	1 set	Brush Holder Plate Assembly	
			3. Main Generator Spares	
	5804490	4 sets	Generator Brushes	
	5823467AB4	1 set	Brush Holder Stud with Insulation	
	5804446	4 sets	Exciter Brushes	
	5822519P1	1 set	Textolite Yoke	
			4. Engine Spares	
	RC-3003	2	Injection Nozzle, Bosch No. ADN4SD24	
	RC-3002	2	Injection Nozzle Holder, Bosch AKB35SD173	
	RC-3228	2	V Belt, Dayton No. 2M056	
	C-90-B	2	Valve Spring	
	R-1790	1	Impeller Seal Assembly Water Pump	
	4R-972-G	1	Valve Cover Gasket	
	R-88	4	Cylinder Head Gasket	
	R-1698	9	Circulating Water Rubber Rings	
	R-1209	1	Gear Case Cover Gasket	
	R-1700	8	Push Rod Rubber Ring	
	RPORG	1	Centrifugal Water Pump Body Gasket	
	R-1619-G	1	Camshaft Thrust Plate Gasket	
	R-1210	1	Flywheel Housing Gasket (upper)	
	R-1211	1	Flywheel Housing Gasket (lower)	
	4R-115-AG	1	Push Rod Cover Plate Gasket	
	4R-115-G	1	Hand Hole Plate Gasket (large)	
	4R-115-AG	1	Hand Hole Plate Gasket (small)	
	4R-669	1	Base Gasket	
	R-1026	1	Lubricating Oil Pump Body Gasket	
	R-1609	1	Governor Flange Gasket	
	R-1729-G	4	Fuel Injection Pump Gasket	
	6R-37-GC	1	Exhaust Manifold Gasket (center)	
	4R-37-GE	2	Exhaust Manifold Gasket (end)	

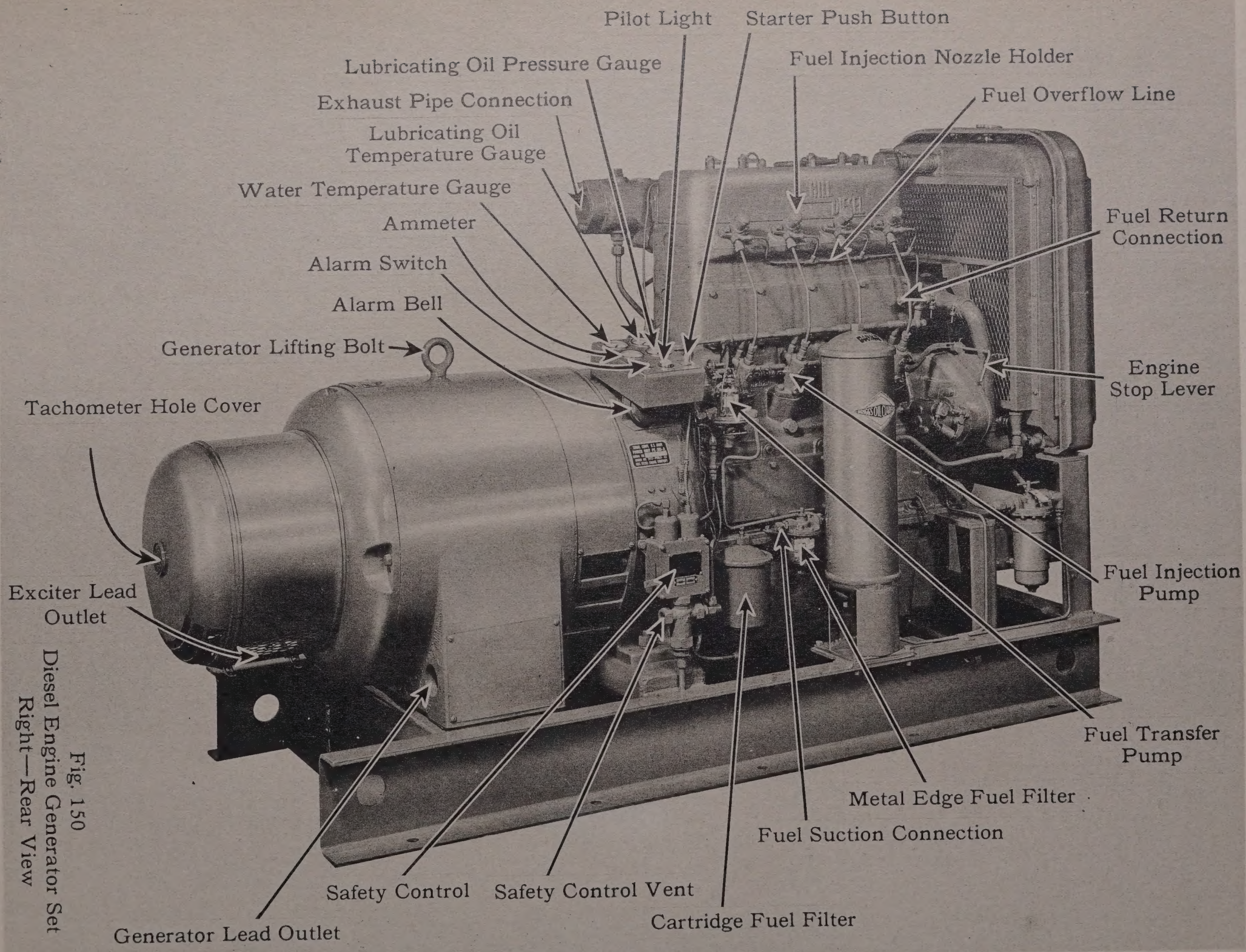
SPARE PARTS LIST

The following spare parts were furnished with each engine-generator set

REF. NUMBER	PART NUMBER	QUANTITY	PART NAME	NOTES
	RF-1894	4	Fuel Pump Priming Plug Gasket	
	R-794-SG	1	Cylinder Water Jacket Cover Gasket	
	B-1608	1	Fuel Transfer Pump Gasket	
	R-638-G	1	Thermostat Housing Gland Gasket	
	R-1364-G	2	Air Filter Gland Gasket	
	10615	1	Cartridge Fuel Filter Cover Gasket	
	10613	1	Cartridge Fuel Filter Top Gasket	
	10613	1	Cartridge Fuel Filter Bottom Gasket	
	10076	1	Cartridge Fuel Filter Cover Bolt Gasket	
	22214	1	Metal-Edge Fuel Filter Head Gasket	
	8262	1	Metal-Edge Lubricating Oil Filter Head Gasket	
	D157	3	Cartridge Lubricating Oil Filter Cover Gasket	
	1521946	1	Fuel Transfer Pump Bowl Gasket	
	855585	1	Fuel Transfer Pump Bottom Cover Gasket	
	1521953	1	Fuel Transfer Pump Valve and Cage Assembly Gasket	
	4R-37-CG	1	Exhaust Manifold End Plate Gasket	
	4R-37-DG	1	Exhaust Gland Gasket	
	R-1614-GC	1	Water Outlet Manifold Gasket, Center	
	R-1614-GE	2	Water Outlet Manifold Gasket, End	
	R-1790	1	Water Pump Impeller Seal Assembly	
	R-1705-G	1	Radiator Gland Gasket	
	R-1698	1	Oil Tube Rubber Ring	
	R-1854-B	1	Oil Filler Cap Gasket	

SECTION IV

PHOTOGRAPHS AND DIAGRAMS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Starter Push Button
Lubricating Oil Pressure Gauge
Fuel Injection Nozzle Holder
Exhaust Pipe Connection
Fuel Overflow Line
Lubricating Oil Temperature Gauge
Water Temperature Gauge
Fuel Return Connection
Ammeter
Alarm Switch
Alarm Bell
Generator Lifting Bolt
Engine Stop Lever
Tachometer Hole Cover
Exciter Lead Outlet
Fuel Injection Pump
Fuel Transfer Pump
Metal Edge Fuel Filter
Fuel Suction Connection
Safety Control
Safety Control Vent
Cartridge Fuel Filter
Generator Lead Outlet

Fig. 150
Diesel Engine Generator Set
Right—Rear View

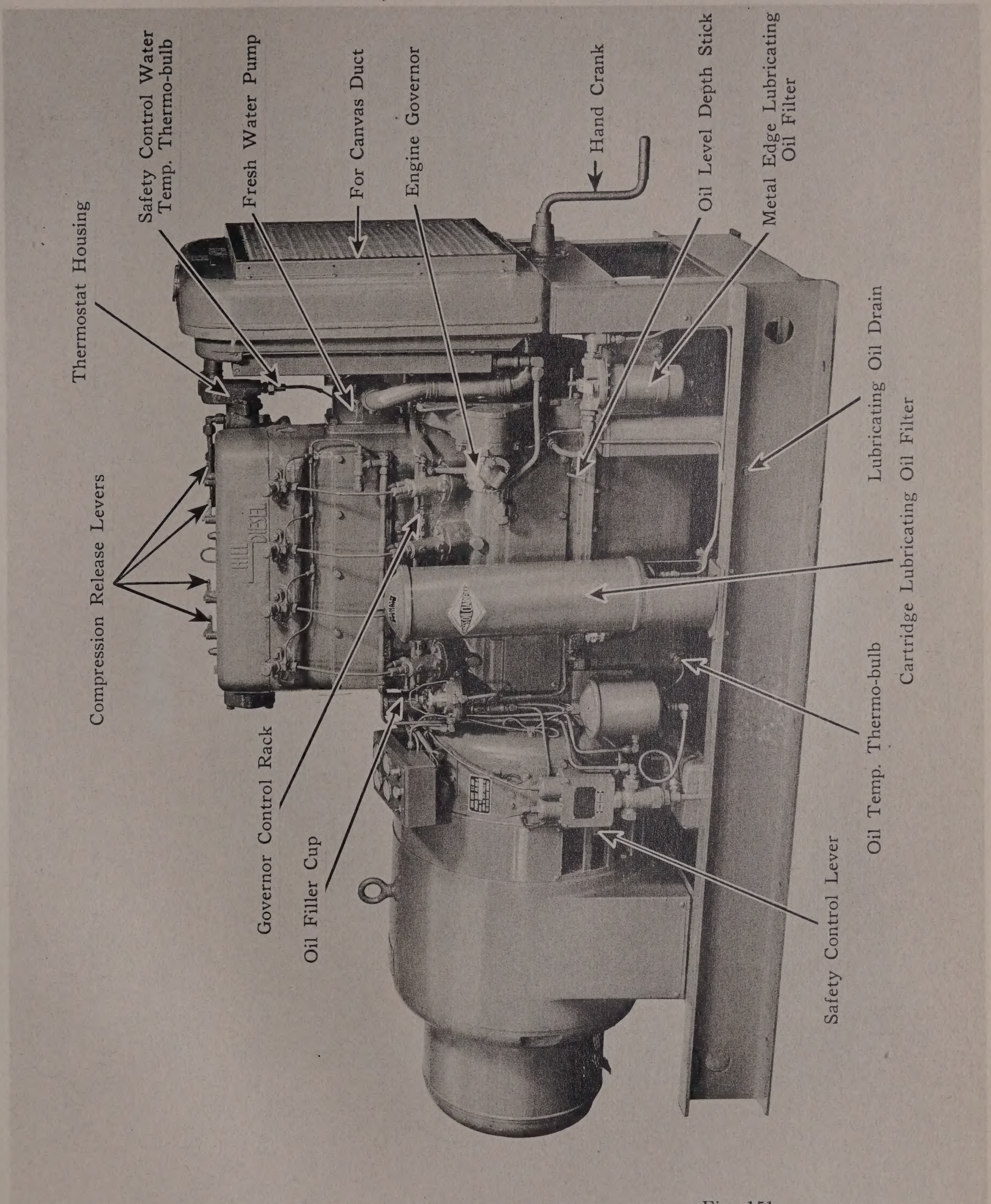

Compression Release Levers
Thermostat Housing
Safety Control Water Temp. Thermo-bulb
Fresh Water Pump
Governor Control Rack
Oil Filler Cup
For Canvas Duct
Engine Governor
Hand Crank
Oil Level Depth Stick
Metal Edge Lubricating Oil Filter
Lubricating Oil Drain
Cartridge Lubricating Oil Filter
Oil Temp. Thermo-bulb
Safety Control Lever
HILL DIESEL

Fig. 151
Diesel Engine Generator Set
Right — Front View

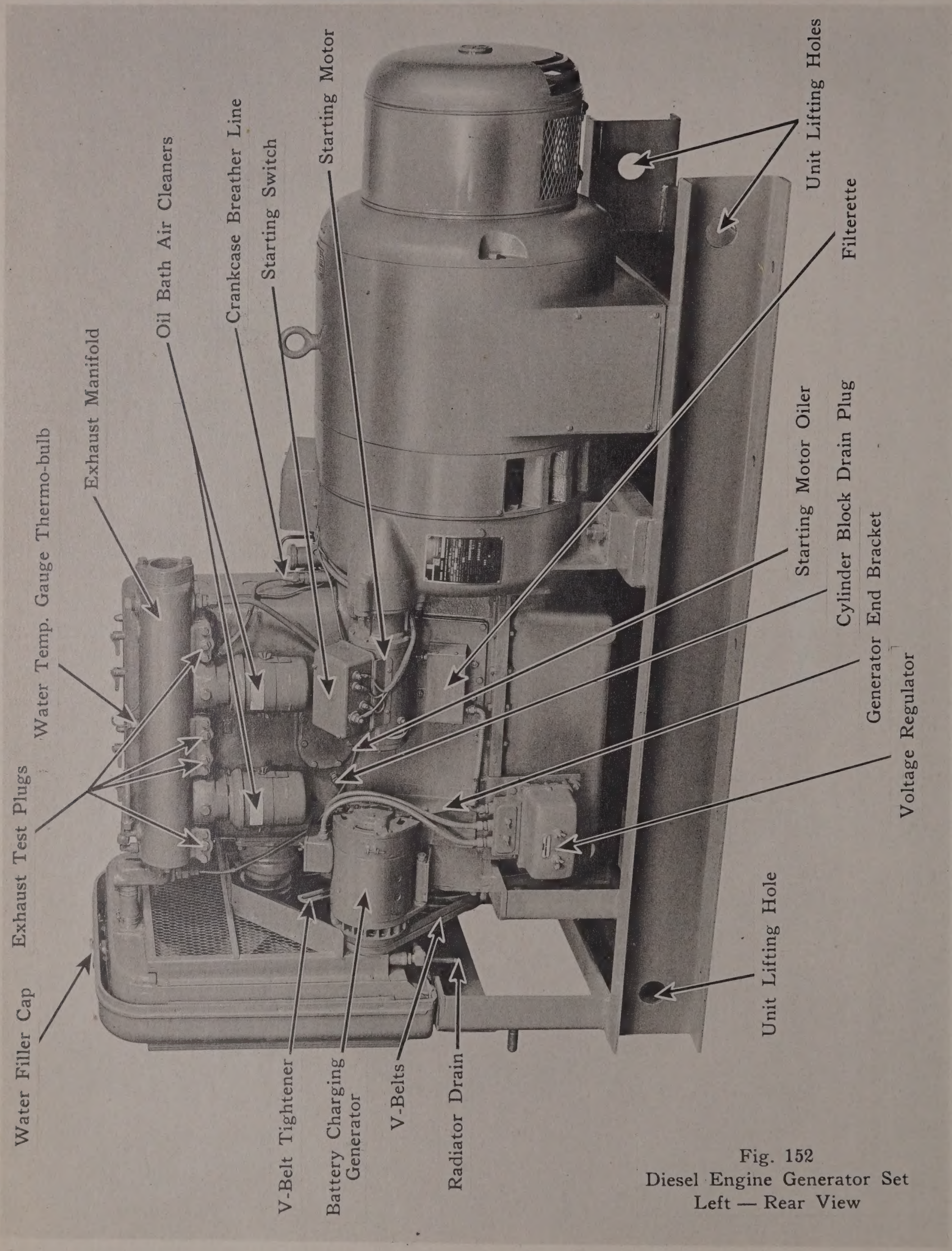

Water Filler Cap
Exhaust Test Plugs
Water Temp. Gauge Thermo-bulb
Exhaust Manifold
Oil Bath Air Cleaners
Crankcase Breather Line
Starting Switch
Starting Motor
Unit Lifting Holes
Filterette
Starting Motor Oiler
Cylinder Block Drain Plug
Generator End Bracket
Voltage Regulator
Unit Lifting Hole
V-Belt Tightener
Battery Charging Generator
V-Belts
Radiator Drain

Fig. 152
Diesel Engine Generator Set
Left — Rear View

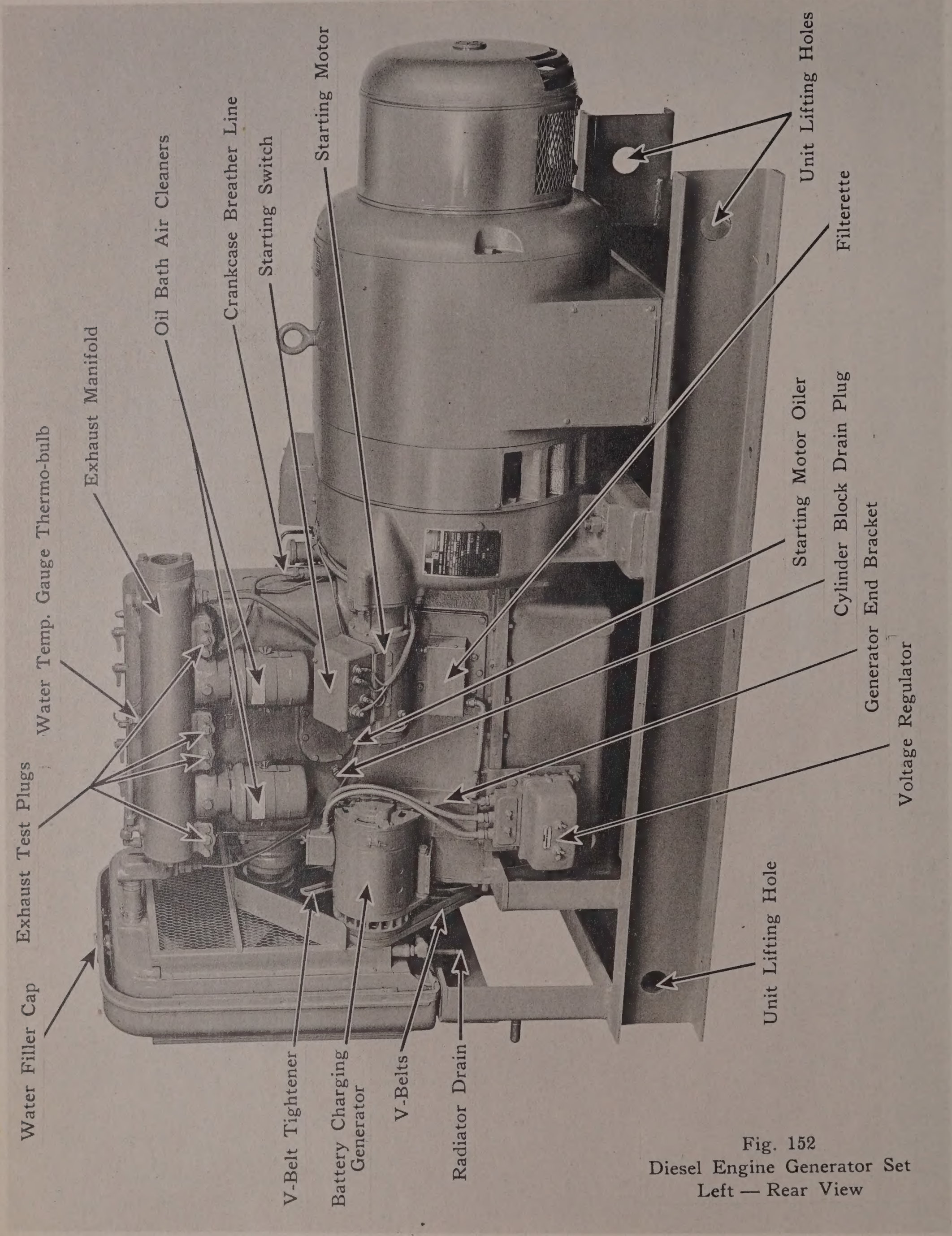
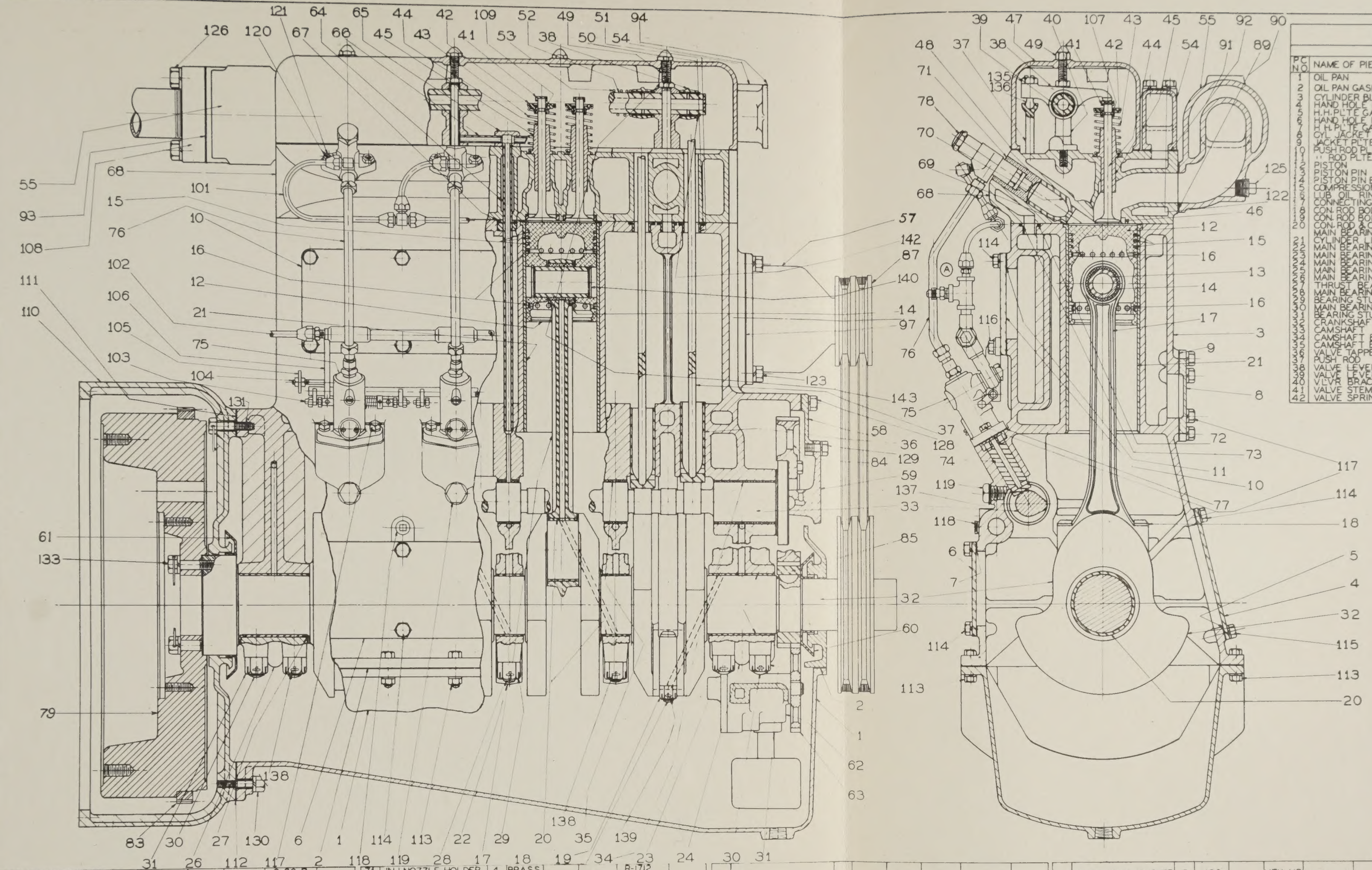

Water Filler Cap
Exhaust Test Plugs
Water Temp. Gauge Thermo-bulb
Exhaust Manifold
Oil Bath Air Cleaners
Crankcase Breather Line
Starting Switch
Starting Motor
Unit Lifting Holes
Filterette
Starting Motor Oiler
Cylinder Block Drain Plug
Generator End Bracket
Voltage Regulator
Unit Lifting Hole
V-Belt Tightener
Battery Charging Generator
V-Belts
Radiator Drain

Fig. 152
Diesel Engine Generator Set
Left — Rear View



LIST OF MATERIAL

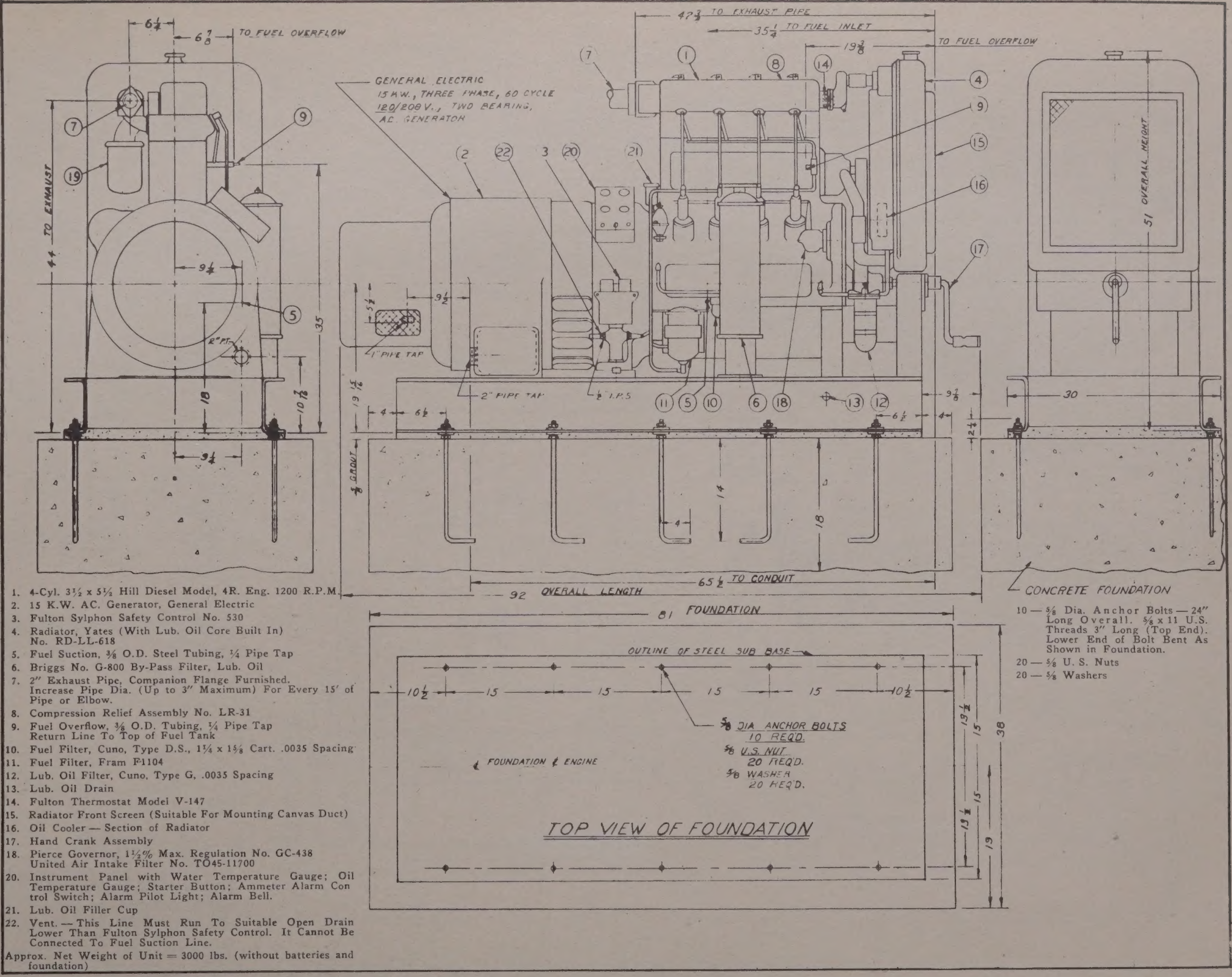
PC NO.	NAME OF PIECE	NO. REQ	MAT'L	M.SPEC	REMARK	DRAWING NUMBERS CONTR'CTR	BUREAU
1	OIL PAN	1	C.I.			4R-1	
2	OIL PAN GASKET	1	444		FIBRE	4R-669	
3	CYLINDER BLOCK	1	C.I.			4R-O	
4	HAND HOLE PLATE	1	STEEL		LARGE	4R-115	
5	H.H.PL'TE GASKET	1	444		FIBRE	4R-115 G	
6	HAND HOLE PLATE	1	STEEL		SMALL	4R-115-A	
7	H.H.PL'TE GASKET	1	444		FIBRE	4R-115-AG	
8	CYL JACKET PLATE	1	C.I.			R-794-S	
9	JACKET PL'TE GASK'T	1	444		FIBRE	R-794-SG	
10	PUSH ROD PLATE	1	STEEL			4R-785	
11	" ROD PLTE GASK'T	1	444		FIBRE	4R-785 G	
12	PISTON	4	LYNITE			R-3	
13	PISTON PIN	4	X-1020		STEEL	R-46	
14	PISTON PIN BUSH	4	BRONZE			R-45	
15	COMPRESSION RINGS	12	IRON			R-16	
16	LUB OIL RINGS	8	"			R-16-A	
17	CONNECTING ROD	4	STEEL			R-51	
18	CON. ROD BOLT	8	STEEL			C-75-A	
19	CON. ROD BOLT NUT	8	"			C-1106	
20	CON. ROD & CENTER MAIN BEARING	7	STEEL BACK		SILVER LINED	C-353-A	
21	CYLINDER LINER	4	IRON			R-1670	
22	MAIN BEARING CAP	3	C.I.		CENTER	R-15	
23	MAIN BEARING	3	HALVES	REAR &	FRONT	C-372-A	
24	MAIN BEARING CAP	1	C.I.		FRONT	R-14-F	
25	MAIN BEARING-LOWER	1			REAR	R-372-R	
26	MAIN BEARING CAP	1	C.I.		REAR	R-14-R	
27	THRUST BEARING	1	BRONZE		REAR	R-372-T	
28	MAIN BEARING STUD	6	STEEL		CENTER	R-60-C	
29	BEARING STUD NUT	6	"		CENTER	C-1106	
30	MAIN BEARING STUD	8	"		END	R-60-E	
31	BEARING STUD NUT	8	"		END	C-1105	
32	CRANKSHAFT	1				4R-50	
33	CAMSHAFT	1				4R-105	
34	CAMSHAFT BUSH	1	DUALOY		FRONT	R-82-F	
35	CAMSHAFT BUSH	3	"		CENTER	R-82-C	
36	VALVE TAPPET	8	STEEL			R-30	
37	PUSH ROD	8	"			R-62	
38	VALVE LEVER	8	"			R-430 R&L	
39	VALVE LEVER BUSH	8	BRONZE			C-1471	
40	V.L'VR BRACKET	4	C.I.			R-786	
41	VALVE STEM CAP	8	STEEL			R-1664	
42	VALVE SPRING CAP	8	"			R-39	
43	VALVE SPRING	8				C-90-B	
44	VALVE	8	STEEL			R-61	
45	V. STEM GUIDE	8	C.I.			R-405	
46	V. SEAT INSERT	8	STEEL			R-1706	
47	VALVE COVER	1	C.I.			4R-972	
48	V. COVER GASKET	1	444		FIBRE	4R-972-G	
49	V. COVER STUD	4	STEEL			R-720	
50	P.R. RUBBER RING	8	RUBBER			R-1700	
51	P.R. BUSHING	8	STEEL			R-1699	
52	VALVE LEVER SHAFT	2	"			2R-973	
53	LEVER SHAFT SPRING	2	"			C-974	
54	WATER OUTLET MFD	1	C.I.			4R 638	
55	EXHAUST MANIFOLD	1	C.I.			4R-37-D	
57	WATER CIRCL. PUMP	1	C.I.			R-781	
58	GEAR CASE	1	"			R-1691	
59	CAM THRUST PLATE	1	C.I.			R-1276-F	
60	FRONT OIL SLINGER	1	STEEL			R-1276 R	
61	REAR OIL SLINGER	1	"			LR-6	
62	LUB OIL PUMP	1				R-650	
63	OIL PUMP GEAR	1				R-1693	
64	VERTICAL OIL TUBE	1	STEEL			4R-1695	
65	OIL TUBE CONNECTN	1	C.I.			R-1694	
66	HORIZONTAL OIL TUBE	2	STEEL			R-1698	
67	TUBE RUBBER RING	1				4R-2-A	
68	CYLINDER HEAD	1	C.I.			R-88	
69	CYL HEAD GASKET	4	COPPER			RF-30	
70	FUEL CUP		STEEL				
71	INJ. NOZZLE HOLDER	4	BRASS			R-1712	
72	WATER RUBBER RING	9				R-1698	
73	WATER BUSHING	8	BRONZE			R-1697	
74	FUEL PUMP TAPPET	4	STEEL			R-1692	
75	FUEL INJ. PUMP	4	STEEL		BOSCH	APF1A80AS54	
76	FUEL INJ. TUBING	4	STEEL			RF-177-B	
77	INJ. PUMP GASKET	4	COPPER		SOFT	R-1729-G	
78	INJECTION NOZZLE	4	STEEL		BOSCH	ADN4SD24	
79	FLYWHEEL	1	C.I.				
80							
83	RING GEAR	1	STEEL			4R 948 A	
84	CAMSHAFT GEAR	1	C.I.			R 6	
85	CRANKSHAFT GEAR	1	STEEL			R 42	
87	W. PUMP SHEAVE	1	C.I.				
89	CENTER GASKET	1				6R 37 GC	
90	END GASKET	2				4R 37 GE	
91	CENTER GASKET	1	444		FIBRE	R-1614GC	
92	END GASKET	2	"		"	R-1614GE	
93	EXHAUST GASKET	1				4R 37 DG	
94	W. MANFD GASKET	1			VELLU'X	R 638 G	
97	W. PUMP GASKET	1				RPORG	
98	THERMOSTAT CASE	1	C.I.				
101	LEAKOFF LINE	1	STEEL	STEEL ON USMC JOBS	FUEL	4R-1867-S	
102	FUEL RAIL	1				4R-1907	
103	GOVERNOR ROD	1	STEEL		FUEL	4R 1781	
104	OVERLOAD STOP	1	"		STUD	R 1887	
105	OVERLOAD STOP	1	"		WASHER	4R 1888	
106	GOV. ROD BRACKET	1	IRON		MALLEABLE	R 1290	
107	V. SPRING RETAINER	8	STEEL			R-671	
108	EXHAUST GLAND	1	C.I.			4R-37-B	
109							
110	FLYWHEEL HOUSING	1	C.I.			4R 783-C	
111	F.W. HOUSE GASKET	1			UPPER	R 1210	
112	F.W. HOUSE GASKET	1			LOWER	R-1211	
114	CAPSCREW & WASHER	26	USS		HEX HD	5/16 x 18 x 5/8	
115	CAPSCREW & WASHER	2	USS		HEX HD	5/16 x 18 x 1/2	
116	CAPSCREW & WASHER	2	USS		HEX HD	5/16 x 18 x 7/8	
117	CAPSCREW & WASHER	16	USS		HEX HD	5/16 x 18 x 1	
118	PIPE PLUG C'SUNK	3	I.P.S.			3/8	
119	FUEL PRIME PLUG	4	STEEL			R-1704	
120	NOZZLE STUD	8	"			RF-32	
121	NOZZLE STUD NUT	8	SAE		HEX	3/8 x 24	
122	CAPSCREW & WASHER	6	USS		HEX HD	3/8 x 16 x 3-1/2	
123	CAPSCREW & WASHER	4	USS			7/16 x 14 x 1-1/2	
125	PIPE PLUG	4	BRASS		I.P.S.	1/2	
126	CAPSCREW & WASHER	2	USS		HEX HD	1/2 x 13 x 2	
128	CAPSCREW & WASHER	9	USS		HEX HD	" x " x 1	
	CAPSCREW NUT & WASH	2	SAE		HEX HD	3/8 x 24 x 3-1/2	
129	CAPSCREW & WASHER	4	USS		HEX HD	3/8 x 16 x 1	
130	CAPSCREW & WASHER	2	USS		HEX HD	3/8 x 16 x 1	
	CAPSCREW & WASHER	3	USS		HEX HD	" x " x 1-1/2	
131	CAPSCREW & WASHER	8	USS		HEX HD	" x " x "	
133	FLYWHEEL BOLT	6	STEEL	FITTED		R-832	
135	ADJSTG SCREW NUT	8	STEEL		VALVE	R-454-A	
136	ADJUSTING SCREW	8	STEEL		VALVE	C-454	
137	PRIME PLUG GASKET	4	COP'R			RF-1894	
138	COTTER PINS	14	SAE			1/8 x 1-1/4	
139	COTTER PINS	8	SAE			1/8 x 1	
140	PISTON PIN LOCK RING	8				R-1772	
141	BOLT LOCK WIRE		B.&S.			20 GAU.	
143	BRACKET NUT	4	S.A.E.		HEX	3/8 x 24	
144							
142	SNAP RING	4	STEEL			R-1771	

MODEL 4R ENGINE
SECTIONAL ASSEMBLY

DRAWN Young CHK D ____ DATE 4-9-42
TRACED HARTER FILE ______ SCALE 6" = 1'

DRAWING NUMBER 4LR 18

Fig. 153 — Cross Section of Model 4R Diesel Engine


6¼
6⅞ TO FUEL OVERFLOW
44 TO EXHAUST
35
9¼
10½
18
9¼
R" P.T.
42⅞ TO EXHAUST PIPE
35¼ TO FUEL INLET
19⅜
TO FUEL OVERFLOW
GENERAL ELECTRIC
15 K.W., THREE PHASE, 60 CYCLE
120/208 V., TWO BEARING,
A.C. GENERATOR
5¼
9½
1" PIPE TAP
2" PIPE TAP
½ I.P.S.
19 1/16
4
6½
9⅞
6½
4
2¼
⅞ GROUT
14
4
18
65½ TO CONDUIT
92 OVERALL LENGTH
81 FOUNDATION
51 OVERALL HEIGHT
30
CONCRETE FOUNDATION
OUTLINE OF STEEL SUB BASE
10½
15
15
15
15
10½
⅝ DIA ANCHOR BOLTS
10 REQD.
⅝ U.S. NUT
20 REQ'D.
⅝ WASHER
20 REQ'D.
℄ FOUNDATION ℄ ENGINE
TOP VIEW OF FOUNDATION
19¼
15
15
19¼
38
19
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

10 — ⅝ Dia. Anchor Bolts — 24" Long Overall. ⅝ x 11 U.S. Threads 3" Long (Top End). Lower End of Bolt Bent As Shown in Foundation.
20 — ⅝ U. S. Nuts
20 — ⅝ Washers

1. 4-Cyl. 3½ x 5½ Hill Diesel Model, 4R. Eng. 1200 R.P.M.
2. 15 K.W. AC. Generator, General Electric
3. Fulton Sylphon Safety Control No. 530
4. Radiator, Yates (With Lub. Oil Core Built In) No. RD-LL-618
5. Fuel Suction, ⅜ O.D. Steel Tubing, ¼ Pipe Tap
6. Briggs No. G-800 By-Pass Filter, Lub. Oil
7. 2" Exhaust Pipe, Companion Flange Furnished. Increase Pipe Dia. (Up to 3" Maximum) For Every 15' of Pipe or Elbow.
8. Compression Relief Assembly No. LR-31
9. Fuel Overflow, ⅜ O.D. Tubing, ¼ Pipe Tap Return Line To Top of Fuel Tank
10. Fuel Filter, Cuno, Type D.S., 1¼ x 1⅝ Cart. .0035 Spacing
11. Fuel Filter, Fram F-1104
12. Lub. Oil Filter, Cuno, Type G, .0035 Spacing
13. Lub. Oil Drain
14. Fulton Thermostat Model V-147
15. Radiator Front Screen (Suitable For Mounting Canvas Duct)
16. Oil Cooler — Section of Radiator
17. Hand Crank Assembly
18. Pierce Governor, 1½% Max. Regulation No. GC-438 United Air Intake Filter No. TO45-11700
20. Instrument Panel with Water Temperature Gauge; Oil Temperature Gauge; Starter Button; Ammeter Alarm Control Switch; Alarm Pilot Light; Alarm Bell.
21. Lub. Oil Filler Cup
22. Vent. — This Line Must Run To Suitable Open Drain Lower Than Fulton Sylphon Safety Control. It Cannot Be Connected To Fuel Suction Line.

Approx. Net Weight of Unit = 3000 lbs. (without batteries and foundation)

Fig. 154 — Installation Drawing

	Weight Lbs.	WR² Lb. Ft²
A.C.Gen. rotor, inc. shaft	308	46
A.C.Generator stator	488	
A.C.Generator, miscellaneous	181	
A.C.Generator, total	977	
Exciter rotor	30	.8
Exciter stator	97	
Exciter total	127	
Total unit	1104	46.8

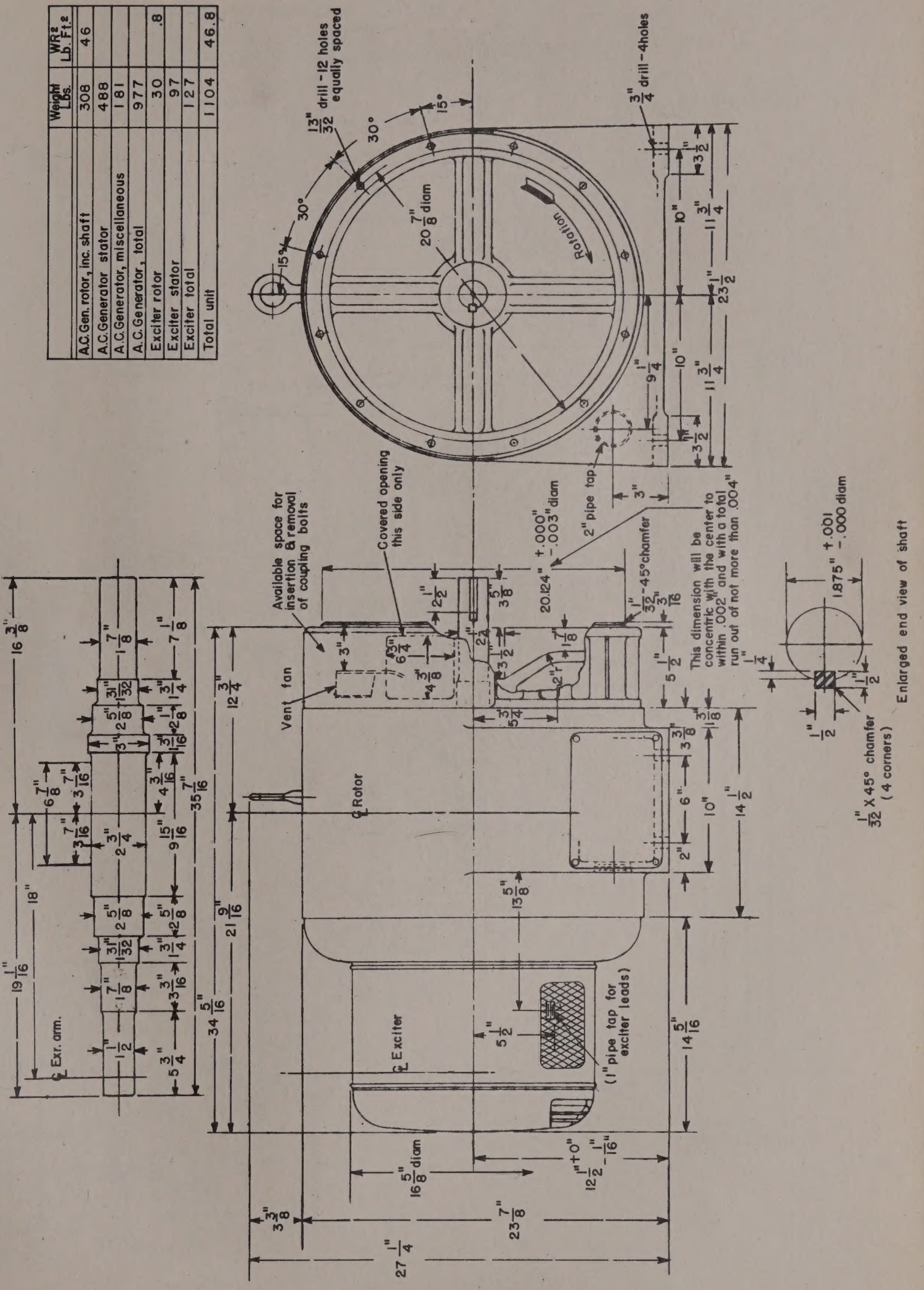

13/32" drill - 12 holes equally spaced
30°
15°
30°
15°
20 7/8" diam
Rotation
3/4" drill - 4 holes
10"
10"
11 3/4"
11 3/4"
23 1/2"
3 1/2"
3 1/2"
9 1/4"
2" pipe tap
3"
Available space for insertion & removal of coupling bolts
Covered opening this side only
20.124" +.000" -.003" diam
1/32"-45° chamfer
This dimension will be concentric with the center to within .002" and with a total run out of not more than .004"
1.875" +.001 -.000 diam
1/32" X 45° chamfer (4 corners)
Enlarged end view of shaft
Vent fan
℄ Rotor
℄ Exciter
℄ Exr. arm.
(1" pipe tap for exciter leads)
16 5/8" diam
12 1/2" +0" -1/16"
23 7/8"
27 1/4"
3 3/8"
34 5/16"
35 7/16"
21 9/16"
12 3/4"
13 5/8"
14 5/16"
14 1/2"
19 1/16"
18"
16 3/8"
6 7/8"
5 3/4"
5 1/2"
5 1/2"
5 3/4"

Fig. 155 — Mounting and Shaft Dimensions

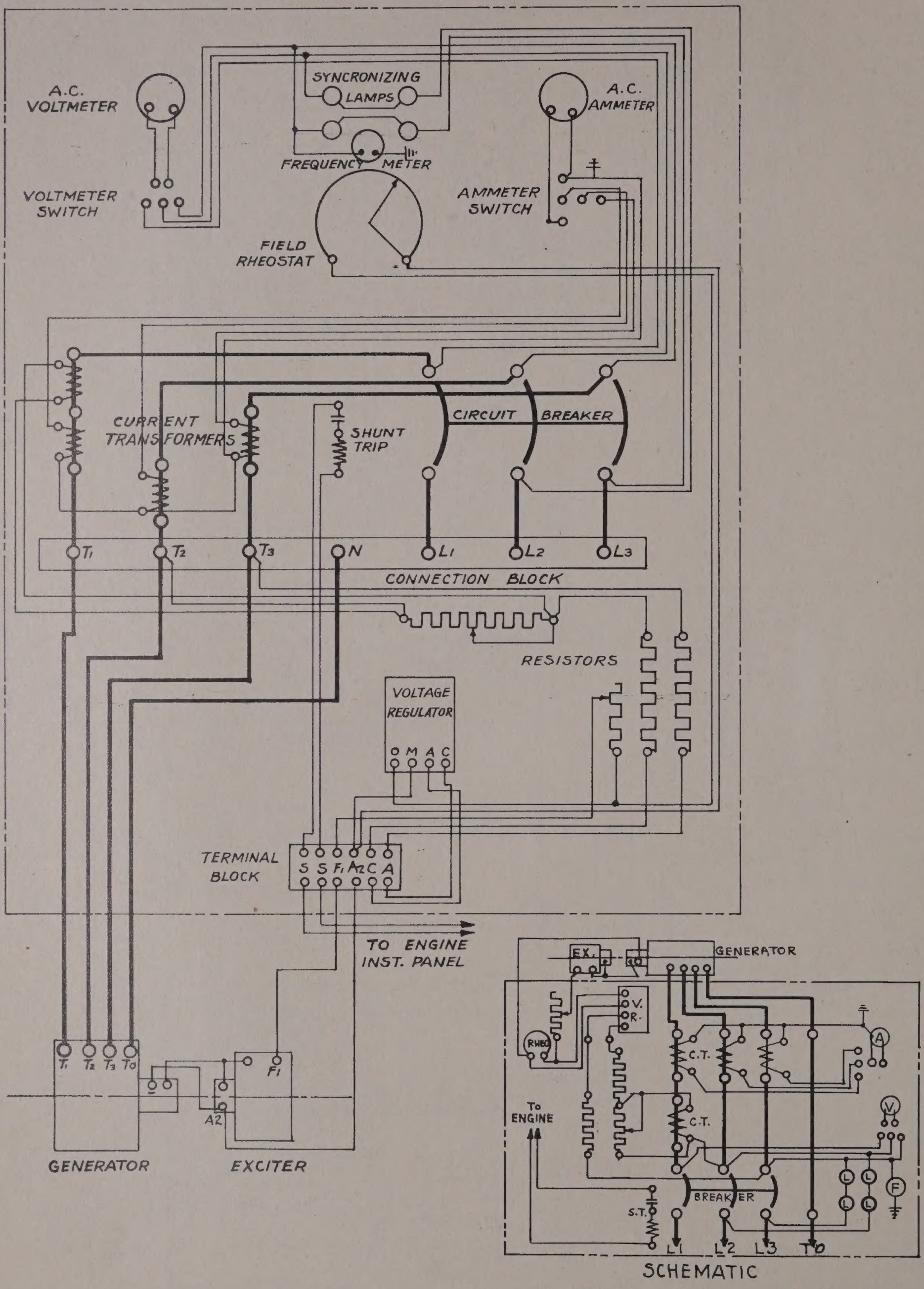

A.C. VOLTMETER
VOLTMETER SWITCH
SYNCRONIZING LAMPS
FREQUENCY METER
FIELD RHEOSTAT
A.C. AMMETER
AMMETER SWITCH
CURRENT TRANSFORMERS
SHUNT TRIP
CIRCUIT BREAKER
T1
T2
T3
N
L1
L2
L3
CONNECTION BLOCK
RESISTORS
VOLTAGE REGULATOR
O M A C
TERMINAL BLOCK
S S F1 A2 C A
TO ENGINE INST. PANEL
T1 T2 T3 T0
F1
A2
GENERATOR
EXCITER
EX.
GENERATOR
V.R.
RHEO
C.T.
C.T.
A
V
To ENGINE
S.T.
BREAKER
L
F
L1 L2 L3 T0
SCHEMATIC

Fig. 156 — Switchboard Connection and Wiring Diagram

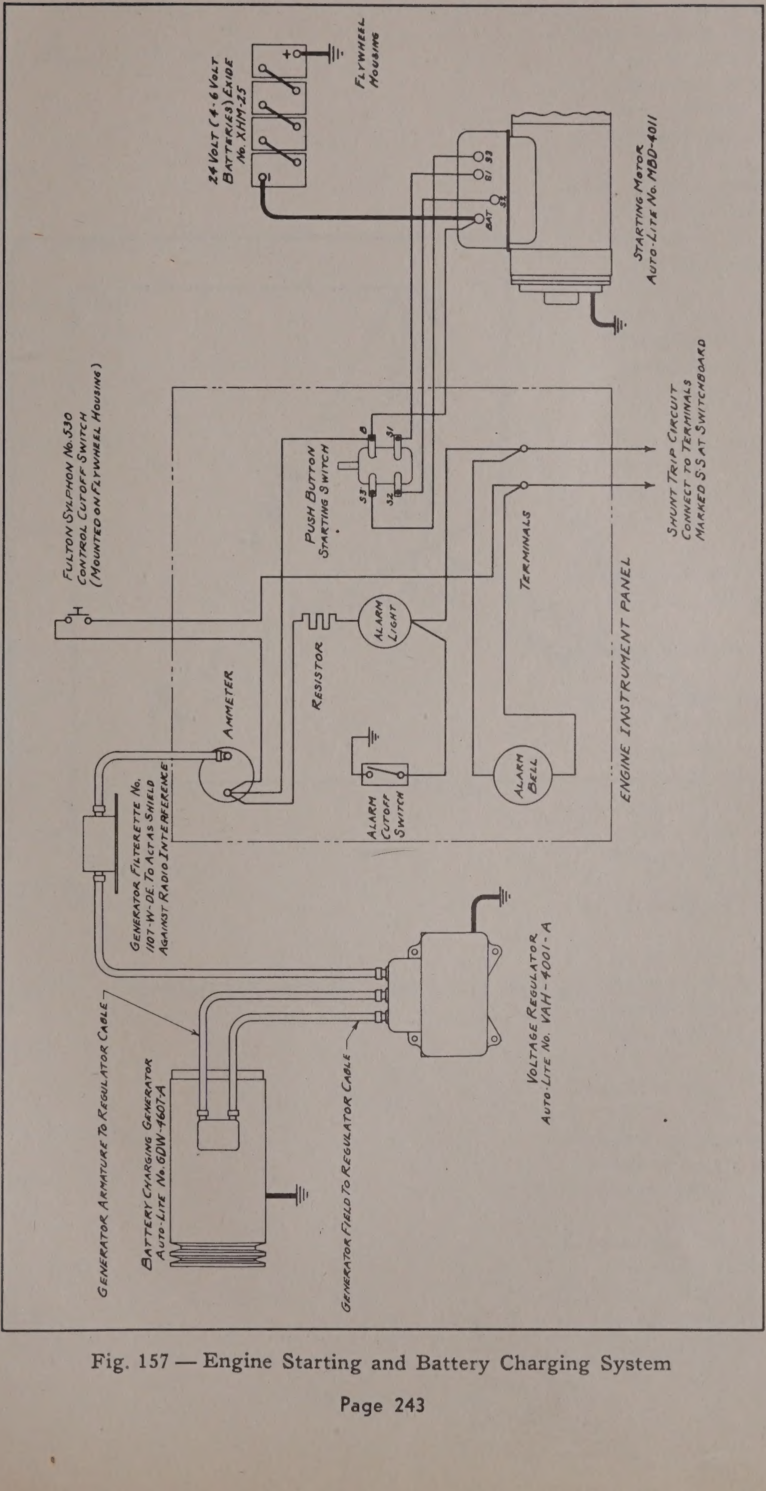

24 Volt (4-6 Volt Batteries) Exide No. XHM-25
Flywheel Housing
S1
S3
BAT
S2
Starting Motor Auto-Lite No. MBD-4011
Fulton Sylphon No. 530 Control Cutoff Switch (Mounted on Flywheel Housing)
B
S1
S3
S2
Push Button Starting Switch
Shunt Trip Circuit Connect to Terminals Marked S-S at Switchboard
Terminals
Alarm Light
Resistor
Ammeter
Alarm Bell
Alarm Cutoff Switch
Engine Instrument Panel
Generator Filterette No. 1107-W-DE. To Act as Shield Against Radio Interference
Voltage Regulator Auto-Lite No. VAH-4001-A
Generator Armature To Regulator Cable
Battery Charging Generator Auto-Lite No. GDW-4607-A
Generator Field To Regulator Cable

Fig. 157 — Engine Starting and Battery Charging System

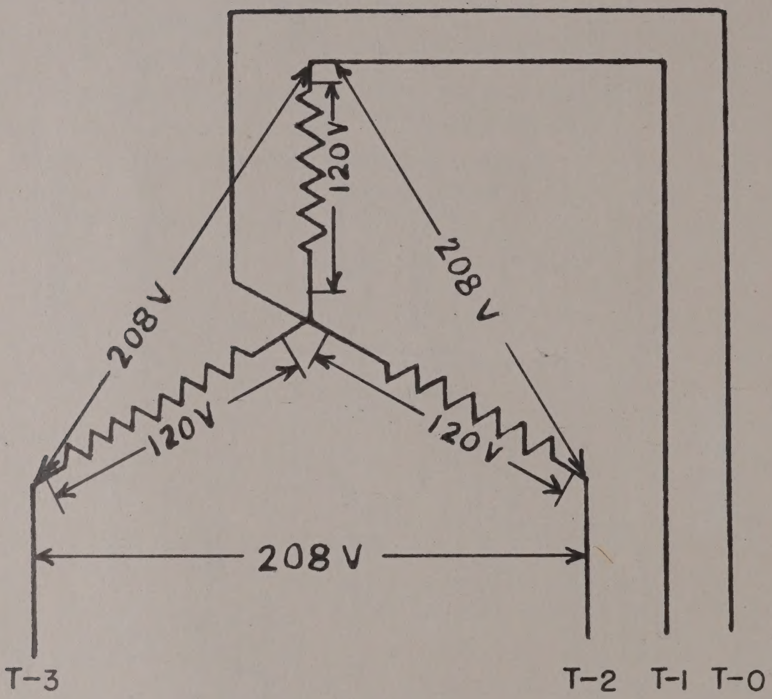

120 V
208 V
208 V
120 V
120 V
208 V
T-3
T-2
T-1
T-0

Fig. 158 — Connection Diagram For Generator

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SERVICE LOG

Date	Log Hours	Operation

SERVICE LOG

Date	Log Hours	Operation

SERVICE LOG

Date	Log Hours	Operation

SERVICE LOG

Date	Log Hours	Operation

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